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Reproductive Biology of Pacific Cod and English Sole from the Cruise of the *FV Blue Waters* to Hecate Strait, January 30 to February 11, 1989

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REPRODUCTIVE BIOLOGY OF PACIFIC COD AND ENGLISH SOLE
FROM THE CRUISE OF THE FV BLUE WATERS TO HECATE STRAIT,
JANUARY 30 TO FEBRUARY 11, 1989

by

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85p.

ABSTRACT

Foucher, R. P., A. V. Tyler, J. Fargo and G. E. Gillespie. 1989. Reproductive biology of Pacific cod and English sole from the cruise of the FV BLUE WATERS to Hecate Strait, January 30 to February 11, 1989. Can. MS Rep. Fish. Aquat. Sci. 2026: 85p.

Pacific cod and English sole were sampled for length, maturity, body and ovary weight and fecundity (Pacific cod) and histology (English sole). Length at 50% maturity for Pacific cod decreased from north to south in Hecate Strait: Two Peaks - 53.1 cm; Reef Island - 40.3 cm. The same trend was observed for English sole: Two Peaks - 36.1 cm; Reef Island - 32.5 cm. Ovary weight vs fish weight showed a linear relationship for Pacific cod and a curvilinear one for English sole. The gonosomatic index (GSI) for Pacific cod varied from 3.59 to 22.93 and for English sole from 0.30 to 1.65. The much higher GSI for Pacific cod reflects the fact that this cruise took place during the spawning season for cod. Length-frequency data confirmed the presence of a strong 1985 year-class of Pacific cod now present as four-year-old fish.

RÉSUMÉ

Foucher, R. P., A. V. Tyler, J. Fargo and G. E. Gillespie. 1989. Reproductive biology of Pacific cod and English sole from the cruise of the FV BLUE WATERS to Hecate Strait, January 30 to February 11, 1989. Can. MS Rep. Fish. Aquat. Sci. 2026: 85p.

On a échantillonné des morues du Pacifique et des soles anglaises pour déterminer des caractéristiques comme la longueur, la maturité, le poids corporel, le poids des ovaires ainsi que la fécondité (morue du Pacifique) et l'histologie (sole anglaise). La longueur a une maturité de 50% dans le cas de la morue du Pacifique a diminué selon un gradient nord-sud dans le détroit d'Hécate: Two Peaks, 53,1 cm; Reef Island, 40,3 cm. La même tendance a été observée dans le cas de la sole anglaise: Two Peaks, 36,1 cm; Reef Island, 32,5 cm. Le poids des ovaires par rapport au poids du poisson a présenté une relation linéaire dans le cas de la morue du Pacifique et une relation curvilinéaire dans le cas de la sole anglaise. L'indice gonadosomatique (IGS) a varié de 3,59 à 22,93 dans le cas de la morue du Pacifique et de 0,30 à 1,65 dans celui de la sole anglaise. L'IGS beaucoup plus élevé de la morue du Pacifique reflète le fait que l'échantillonnage a eu lieu durant le frai de la morue. Les données sur la fréquence des longueurs ont confirmé la présence d'une classe d'âge 1985 forte de morue du Pacifique, (poissons âgés actuellement de quatre ans).

INTRODUCTION

This report presents the results of the fourth cruise in a series in Hecate Strait to study the reproductive biology of Pacific cod (Gadus macrocephalus) and English sole (Parophrys vetulus) (Foucher et al. 1987, Tyler et al. 1987, Tyler et al. 1988). The objectives were: for Pacific cod, to take biological samples to describe fecundity as a function of body weight and age; for English sole, preserve samples of the ovaries for histological preparation for microscopic examination of the progression of oocyte development; and, for both species, collect samples to determine the gonosomatic index, sex ratio, size at 50% maturity, and ovary ripening stage for description of the annual maturation cycle.

MATERIALS AND METHODS

The grounds fished were, from north to south, Two Peaks, Butterworth, White Rocks, Horseshoe and Reef Island (Fig. 1). These grounds are sufficiently far apart that differences in biological responses are possible. Positions of the trawl sets were determined at the discretion of the vessel Captain. The trawl used was a U.R.I. 340 which is a modified Yankee 41. It had a 64-m bridle/sweep line length, a 24-m headrope, and a 31-m footrope. The mesh size was 14 cm throughout.

The entire catch was dumped from the codend directly into the fish hopper. A conveyor belt carried fish to the processing room of the vessel where all Pacific cod and English sole were sorted into plastic baskets. The entire catch of the two species was weighed using a platform balance. Sometimes additional sets at one ground were made to complete a representative sample of either English sole, or Pacific cod. In order to take weights of fish and ovaries, the vessel left the grounds after a representative sample was achieved, and found a protected anchorage during the afternoon and evening of each day.

All cod were measured for length, by sex, and, in eight sets, they were all assigned maturity stages. The aim was to get a representative sample of 400 fish from each fishing ground. This was achieved for three of the five grounds. Sub-samples were taken for determination of cod fecundity according to a length-stratification plan (Table 1) to ensure the widest possible range was represented. Weights were taken to the nearest gram, with stomachs emptied of all contents. Both ovaries were removed from the fish and weighed. Cod ovaries were preserved in 70% ethanol

for later fecundity counts. For better preservation, they were sliced repeatedly once in the preservative.

For English sole, either the entire catch or a known portion was measured for length by sex, and whether they were mature or immature. The objective was a length, by sex, sample of 300 fish. After a minimum of 300 had been sampled from a ground, sole from subsequent hauls on that ground were sampled only for length by sex. Sub-samples were taken for histological preparations for maturation (ripening) stage and oocyte description as indicated in Table 1. Weights were taken, as for Pacific cod, but only the right ovary was removed and weighed. Ovaries were preserved in buffered formal saline for later histological preparation.

Buffered formal saline was made up (for 20 l of solution) as follows:

2 l formalin	80 g NaH_2PO_4
18 l water	130 g Na_2HPO_4
	180 g NaCl

Temperature profiles were to be taken by expendable bathythermograph, but the recorder malfunctioned before any data could be taken. Consequently, only sea-surface temperatures (SST) could be taken at each of the fishing grounds. It is well known, however, that, in February, mixing is nearly complete at depths to 100 m in Hecate Strait, with bottom temperatures approximately equal to the sea surface temperature (e.g., Foucher et al. 1987).

Two methods were used to determine length at which 50% of the fish were mature. The first method was by linear regression of percentage mature versus length, including only those lengths for which 10 to 90% of the fish were mature to avoid the tails of the distribution. The regression was weighted by the number of fish in each length interval. For Pacific cod, this could not be done for most of the individual grounds because of the low sample numbers of smaller fish. The second was the maximum likelihood method of Welch and Foucher (1988) doing iterative fitting to the logistic function. We used their equation 5 to estimate parameters from which lengths at 50% maturity were estimated using their equation 6. In an earlier cruise (Tyler et al. 1988), the results were indistinguishable between the two methods.

RESULTS

Fifteen trawl sets were made from February 4-9: Two Peaks-4; White Rocks-5; Butterworth-2; Horseshoe-2; and Reef Island-2. Figure 1 shows the positions of the hauls. Bridge-log information is given in Appendix Table 1.

A total of 2559 Pacific cod and 2556 English sole were measured. Length-frequency data for Pacific cod included 94 immature females, 1266 mature females, 89 unstaged females and 1110 males. For English sole, the data included 669 immature females, 440 mature females, 501 unstaged females and 946 males. Tables 2 and 3 summarize, by sex, maturity, ground and haul, the length-frequency sampling completed for Pacific cod and English sole respectively. Table 4 presents a detailed description of the criteria used to distinguish maturity stages of Pacific cod. Tables 5 and 6 summarize, by size range and ground, the sampling completed for other sample types for Pacific cod and English sole respectively. Table 7 shows temperature data taken in conjunction with eight of the hauls.

LENGTH FREQUENCY AND SIZE-AT-MATURITY FOR PACIFIC COD

Pacific cod length frequencies are summarized for all grounds combined, Two Peaks, Butterworth, White Rocks, Horseshoe, and Reef Island in Figures 3-8 respectively (see also Appendix Tables 2 and 3). Figures 3-8 each show immature, mature and all the females and all the males. The length composition is very similar between grounds with the dominant length mode corresponding to age-4 fish of the 1985 year-class in all cases except Reef Island, where older fish are more dominant (Figure 8). The strong representation of the 1985 year-class is consistent with other observations which suggested that this was one of the strongest year-classes observed in Hecate Strait (Tyler and Foucher 1989). There were insignificant numbers of age-1 fish captured.

Size at 50% maturity (Figures 9-14) for Pacific cod was smallest at Reef Island, with the difference being equivalent to fish a year younger than at other grounds. This confirms earlier reports of a much smaller size at 50% maturity for the Reef Island Ground (Welch and Foucher 1988). Size at 50% maturity was somewhat larger at Two Peaks compared to White Rocks and Horseshoe grounds, as was found in 1987 (Tyler et al. 1988).

The lengths at 50% maturity as determined by the two methods were:

	All grounds	Two Peaks	Butterworth	White Rocks	Horse-shoe	Reef Island
Linear regression	44.4	48.6	-	-	-	-
Maximum likelihood	48.4	53.1	49.4	51.9	50.1	40.3

GONOSOMATIC INDEX AND FECUNDITY SAMPLES FOR PACIFIC COD

Ovary weight vs fish weight showed a linear relationship:

$$\text{Ovary wt} = 0.196(\text{fish wt}) - 196; r^2 = 0.817 \text{ (Figure 15)}$$

The GSI (ovary weight x 100/whole body weight) ranged from 3.59 to 22.93 with the high values reflecting the fact that sampling occurred during the spawning season. There was no significant relationship between GSI and fish length or body weight. Ovaries were preserved from 67 mature female Pacific cod, mainly from White Rocks Ground, for later determination of fecundity (Table 5). A size range of 44 to 82 cm was sampled.

SEX RATIOS FOR PACIFIC COD

The overall sex ratio, males:females was 0.77, for all grounds combined. There were fewer males than females at Two Peaks (males:females = 226:358 = 0.63), Butterworth (males:females = 139:241 = 0.58) and Reef Island (males:females = 108:200 = 0.54). There were about equal numbers at White Rocks (males:females = 227:229 = 0.99) and Horseshoe (males:females = 410:407 = 1.01). In some cases, there was considerable among-haul variation for individual grounds: Two Peaks, haul 12 = 0.42, haul 13 = 0.88; White Rocks, haul 4 = 1.11, haul 5 = 0.71; and Horseshoe, haul 8 = 0.75, haul 9 = 1.08. This would tend to lessen the significance of the between-ground variation observed.

LENGTH FREQUENCY AND SIZE-AT-MATURITY FOR ENGLISH SOLE

English sole length frequencies are summarized for all grounds combined, Two Peaks, Butterworth, White Rocks and Reef Island in Figures 16-20 respectively. Length-frequency histograms showed a decrease in size from north to south, with the greatest difference being between White Rocks and Reef Island, the two most widely separated grounds. This decrease was consistent among all four categories represented in the Figures.

Size at 50% maturity (Figures 21-25) for English sole also showed a decrease from north to south with a range in means of 3.6 cm. The smallest mature fish were 29 cm, and the largest immature individual was 42 cm.

The lengths at 50% maturity as determined by the two methods were:

	All grounds	Two Peaks	Butter- worth	White Rocks	Reef Island
Linear regression	35.2	36.1	35.4	36.0	33.5
Maximum likelihood	35.1	36.1	35.7	34.6	32.5

GONOSOMATIC INDEX AND HISTOLOGICAL SAMPLES FOR ENGLISH SOLE

Ovaries were preserved from 80 mature female English sole from White Rocks Ground for histological studies. A size range of 31 to 54 cm was sampled.

The linear relationship between ovary weight (right ovary) and fish weight was:

$$\text{Ovary wt} = 0.0151(\text{fish wt}) - 3.72; r^2 = 0.911.$$

The plot of ovary weight vs fish weight, however, showed a more curvilinear relationship (Figure 26). The following relationship:

$$\text{Ovary wt} = -0.00032(\text{fish wt}) + 0.000010(\text{fish wt})^2 + 1.04,$$

produced a better fit: $r^2 = 0.939$.

The GSI ranged from 0.30 to 1.65. It should be noted that only the right ovary, the larger of the two, was removed. There were significant relationships between GSI and both body weight and body length:

GSI = $-0.727 + 0.0381 [\text{length (cm)}]$; $r^2 = 0.584$
(Figure 27)

GSI = $0.319 + 0.000759 [\text{weight (g)}]$; $r^2 = 0.613$
(Figure 28)

SEX RATIOS FOR ENGLISH SOLE

The overall sex ratio, males:females was 0.59, for all grounds combined. There were generally somewhat fewer males than females: Butterworth (males:females = 218:242 = 0.90); White Rocks (males:females = 447:543 = 0.82); and Reef Island (males:females = 167:216 = 0.77). In the case of Two Peaks, there were far fewer males (males:females = 114:609 = 0.19). As with Pacific cod, there were some considerable among-haul variations in sex ratio: White Rocks, haul 1 = 0.67, haul 3 = 1.01; Reef Island, haul 6 = 0.67, haul 7 = 0.84. For Two Peaks Ground, the low proportion of males was consistent: haul 10 = 0.20, haul 11 = 0.17.

ACKNOWLEDGEMENTS

Dave Lorette, the skipper of the vessel, was consistently able to locate just the fish we were looking for. Our thanks go to him and his crew for helping us to achieve our objectives.

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Table 1. Sampling schedule for English sole and Pacific cod (both mature females only) for the FV BLUE WATERS cruise to Hecate Strait, January 30-February 11, 1989.

Species	Sample type	Size range(cm)	Interval size(cm)	Number/ interval	Total number
English sole	Histology	25 - 50	5	15	75
Pacific cod	Fecundity	40 - 90	5	10	100

Table 2. Pacific cod numbers sampled, by ground, by haul, by sex, by maturity (females only), and by sample type, during the FV BLUE WATERS cruise to Hecate Strait, January 30 - February 11, 1989.

		Length-sex						
		Females ^a						
Ground	Haul	Immature	Mature	Unstaged	Males	Total	Fecundity	Histology
White Rocks	1	-	14	-	discarded	14	14	-
	2	-	-	-	-	-	-	-
	3	-	-	2	2	4	-	-
	4	15	143	-	176	334	38	1
	5	-	-	69	49	118	8	-
Reef Island	6	2	57	-	28	87	-	-
	7	4	137	-	80	221	4	-
Horseshoe	8	4	88	-	69	161	2	-
	9	2	313	-	341	656	1	-
Two Peaks	10	-	-	11	15	26	-	-
	11	-	-	7	4	11	-	-
	12	28	172	-	84	284	-	-
	13	21	119	-	123	263	-	4
Butterworth	14	-	-	-	-	-	-	-
	15	18	223	-	139	380	-	-
Total		94	1266	89	1110	2559	67 ^b	5 ^b

^a See appendix table 2 for numbers of females by maturity stages 1-7 (except haul 1).

^b Included in length-sex total.

Table 3. English sole numbers sampled, by ground, by haul, by sex, by maturity (females only), and by sample type, during the FV BLUE WATERS cruise to Hecate Strait, January 30-February 11, 1989.

Length-sex							
Females							
Ground	Haul	Immature	Mature	Unstaged	Males	Total	Histology
White Rocks	1	216	88	-	205	509	80
	2	-	-	-	-	-	-
	3	-	-	239	242	481	-
	4	-	-	-	-	-	-
	5	-	-	-	-	-	-
Reef Island	6	61	28	-	60	149	-
	7	103	24	-	107	234	-
Horseshoe	8	-	-	-	-	-	-
	9	-	-	-	-	-	-
Two Peaks	10	149	198	-	69	416	-
	11	-	-	262	45	307	-
	12	-	-	-	-	-	-
	13	-	-	-	-	-	-
Butterworth	14	140	102	-	218	460	-
	15	-	-	-	-	-	-
Total		669	440	501	946	2556	80 ^a

^a Included in length-sex total.

Table 4. Description of maturity stages for female Pacific cod used to assign maturity stages during the FV BLUE WATERS cruise to Hecate Strait, January 30-February 11, 1989.

Stage	Maturity	Description
1	Immature	Ovaries small, white and somewhat translucent, little more than smooth, clear strings from anterior origin to oviduct, sometimes thickening.
2	Immature (maturing)	Ovaries small, but with definite elongated shape. May be becoming pinkish. No visible oocytes or prominent blood vessels. Diameter usually less than 2 cm. Still occur in fish in 40-50 cm range and occasionally larger.
3	Early ripe (Mature)	Ovaries large, opaque, creamy orange. Blood vessels prominent. Ovary size depends on size of fish but likely to be at least 1 cm in diameter by 5 cm in length, larger in older fish. Oocytes may be visible, at least if ovary is cut. May have some black or silvery coloring to ovary wall if fish has spawned previously. Very unlikely to occur in fish below 40 cm.
4	Late ripe (mature)	Ovaries large, oocytes visible, creamy-yellow. Ovary size could be 3 or 4 cm or larger in diameter and 10 or more cm in length. Individual oocytes visible through any translucent parts of the ovary wall. May contain a few translucent eggs.
5	Running ripe (mature)	Ovaries very large, each ovary from a large fish may be 1 litre in volume. Externally, the fish will look obviously gravid. Ovary wall with thin, stretched appearance. Most eggs translucent. Eggs may flow from vent if fish is squeezed.
6	Spent (mature)	Ovaries medium in outline but flaccid. Flaccid condition probably does not last long. Ovaries dark and bloodshot with reddish-brown interior. May be a few translucent eggs remaining.
7	Resting (mature)	Ovaries small, firm, may have some black or silver colour.

Adapted from Westrheim 1977.

Table 5. Pacific cod fecundity samples collected, by area, by length interval during the FV BLUE WATERS cruise to Hecate Strait, January 30-February 11, 1989.

Length interval (cm)	Number sampled by area		
	Horseshoe	Reef Island	White Rocks
40 - 44	-	1	-
45 - 49	-	-	-
50 - 54	1	2	7
55 - 59	-	-	9
60 - 64	-	-	10
65 - 69	-	-	10
70 - 74	-	-	11
75 - 79	1	-	10
80 - 84	1	1	3
Total	3	4	60

Table 6. English sole histology samples collected by length interval, from White Rocks Ground during the FV BLUE WATERS cruise to Hecate Strait, January 30-February 11, 1989.

Length interval (cm)	Number sampled
30 - 34	18
35 - 39	20
40 - 44	14
45 - 49	15
50 - 54	13
Total	80

Table 7. Surface water temperatures, by ground, by haul and date, during the FV BLUE WATERS cruise to Hecate Strait, January 30-February 11, 1989.

Ground	Haul	Date	Temperature (°C)
White Rocks	1	Feb. 4	5.4
"	3	5	5.9
"	4	5	6.0
"	5	5	6.1
Reef Island	6	6	6.1
Two Peaks	10	7	6.1
"	11	7	6.0
Butterworth	14	8	5.6

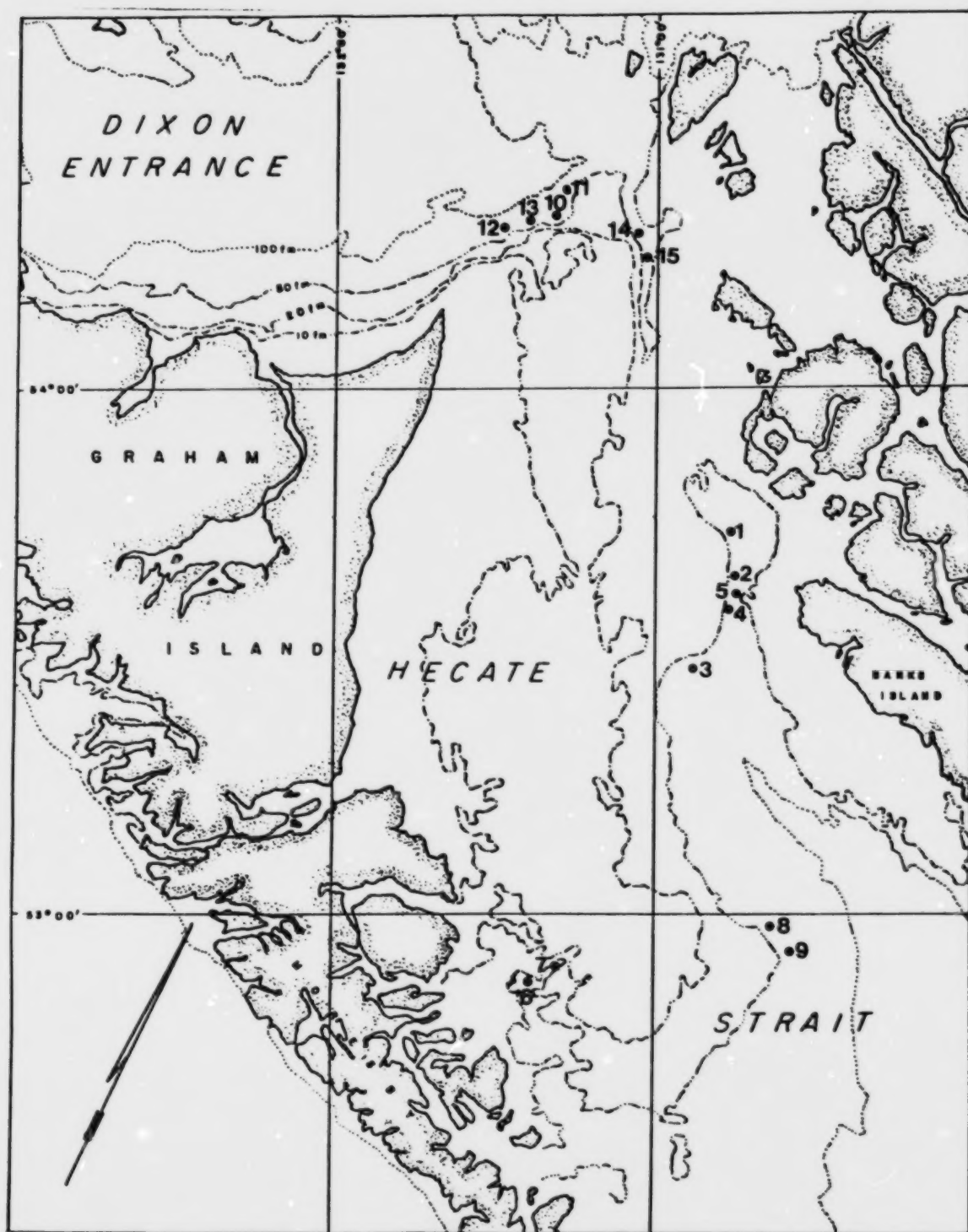


Fig. 1. Haul locations for FV BLUE WATERS cruise to Hecate Strait, January 30 - February 11, 1989.



NET DIMENSIONS AND CHARACTERISTICS FOR BOTTOM TRAWL
 VESSEL FV BLUE WATERS NET U.R.I. 340 (converted Yankee 41)
 OBSERVATION PERIOD January 30 - February 11, 1989

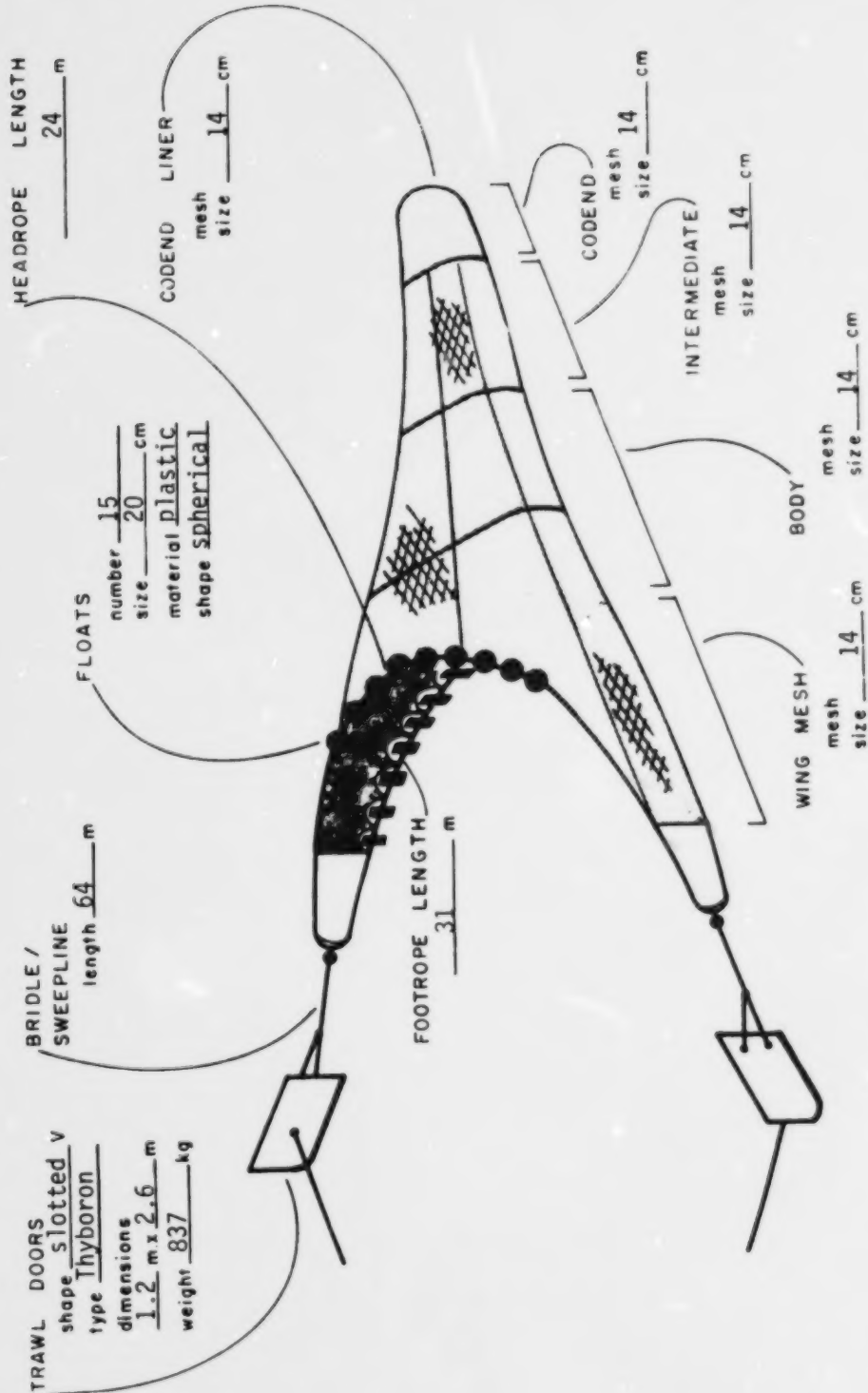


Fig. 2.

1

2

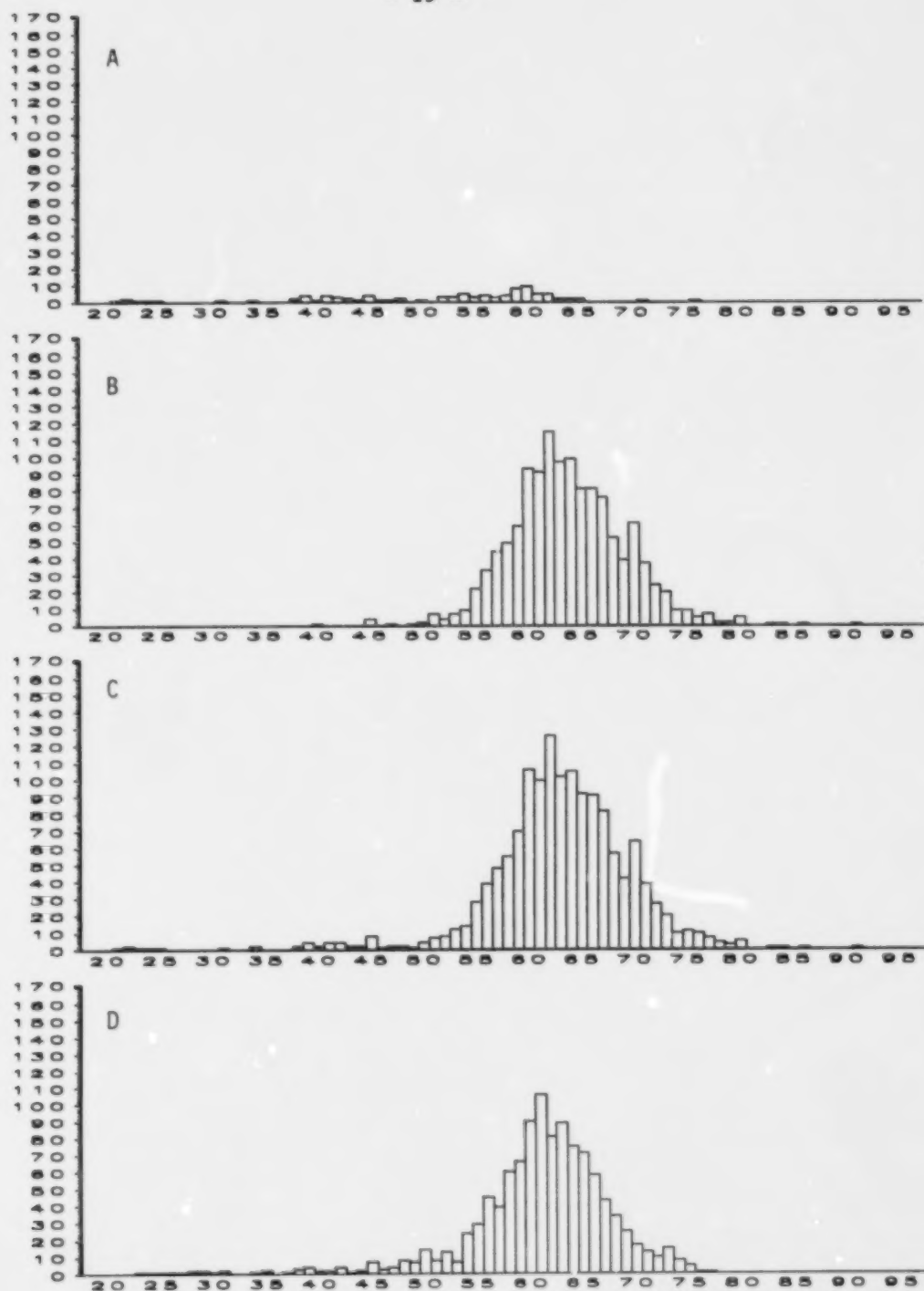


Fig. 3. Length frequency of Pacific cod from all areas combined.
A) immature females, N=94; B) mature females, N=1252; C) all females, N=1412; D) males, N=1130.



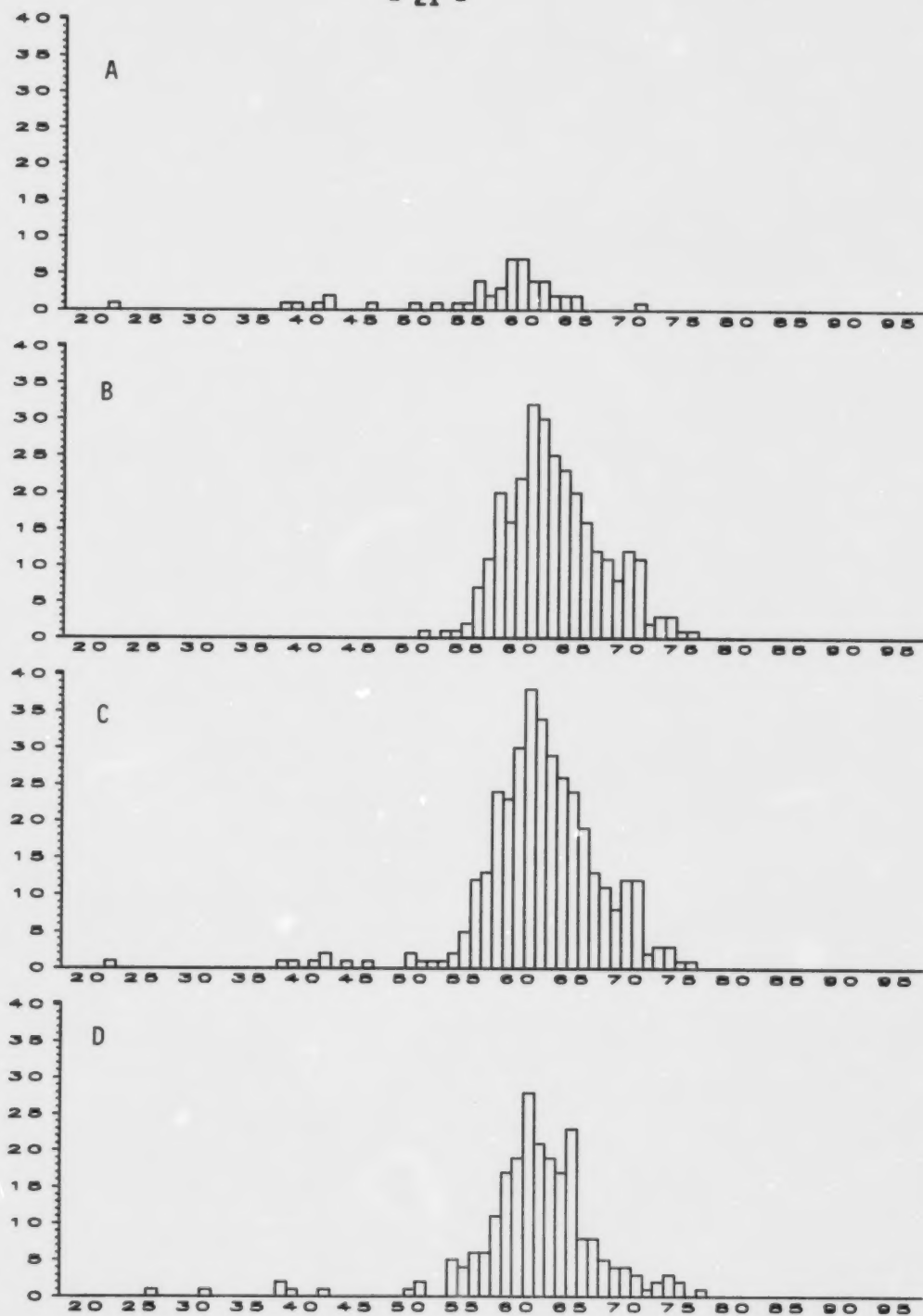


Fig. 4. Length frequency of Pacific cod from Two Peaks A) immature females, N=49; B) mature females, N=291; C) all females, N=358; D) males, N=226.



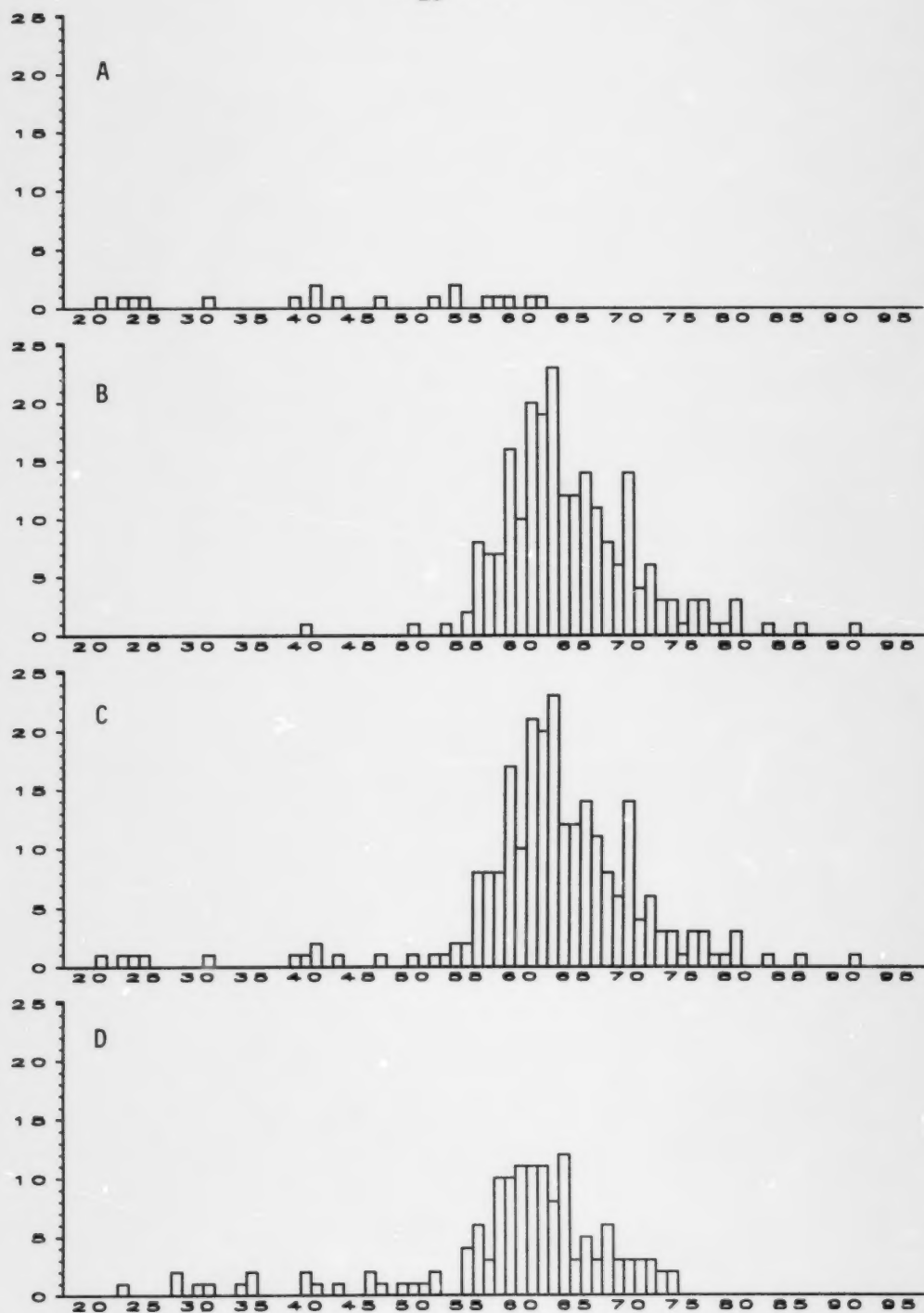


Fig. 5. Length frequency of Pacific cod from Butterworth A) immature females, N=18; B) mature females, N=223; C) all females, N=241; D) males, N=139.



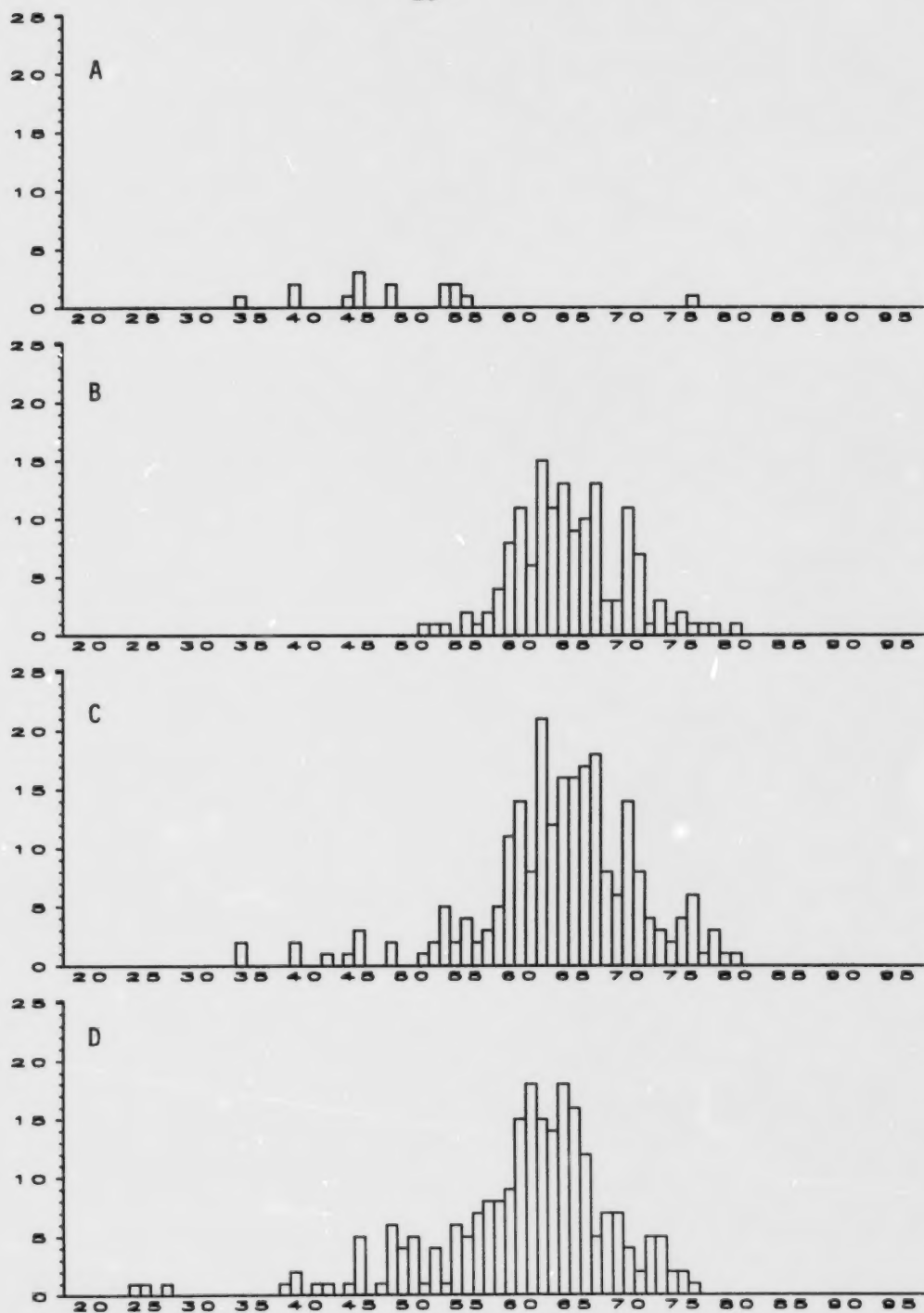


Fig. 6. Length frequency of Pacific cod from White Rocks A) immature females, N=15; B) mature females, N=143; C) all females, N=229; D) males, N=227.



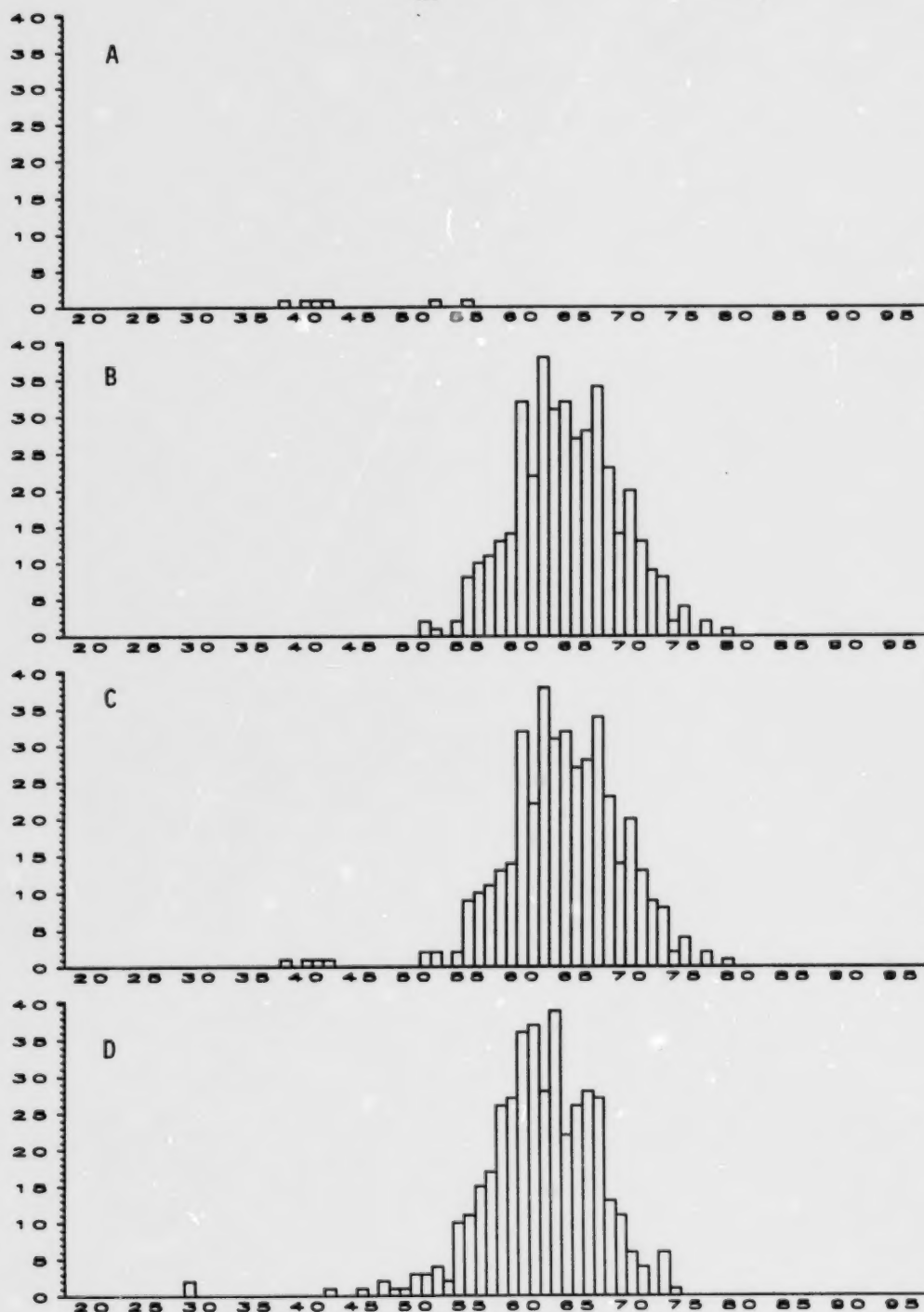


Fig. 7. Length frequency of Pacific cod from Horseshoe A) immature females, N=6; B) mature females, N=401; C) all females, N=407; D) males, N=410.



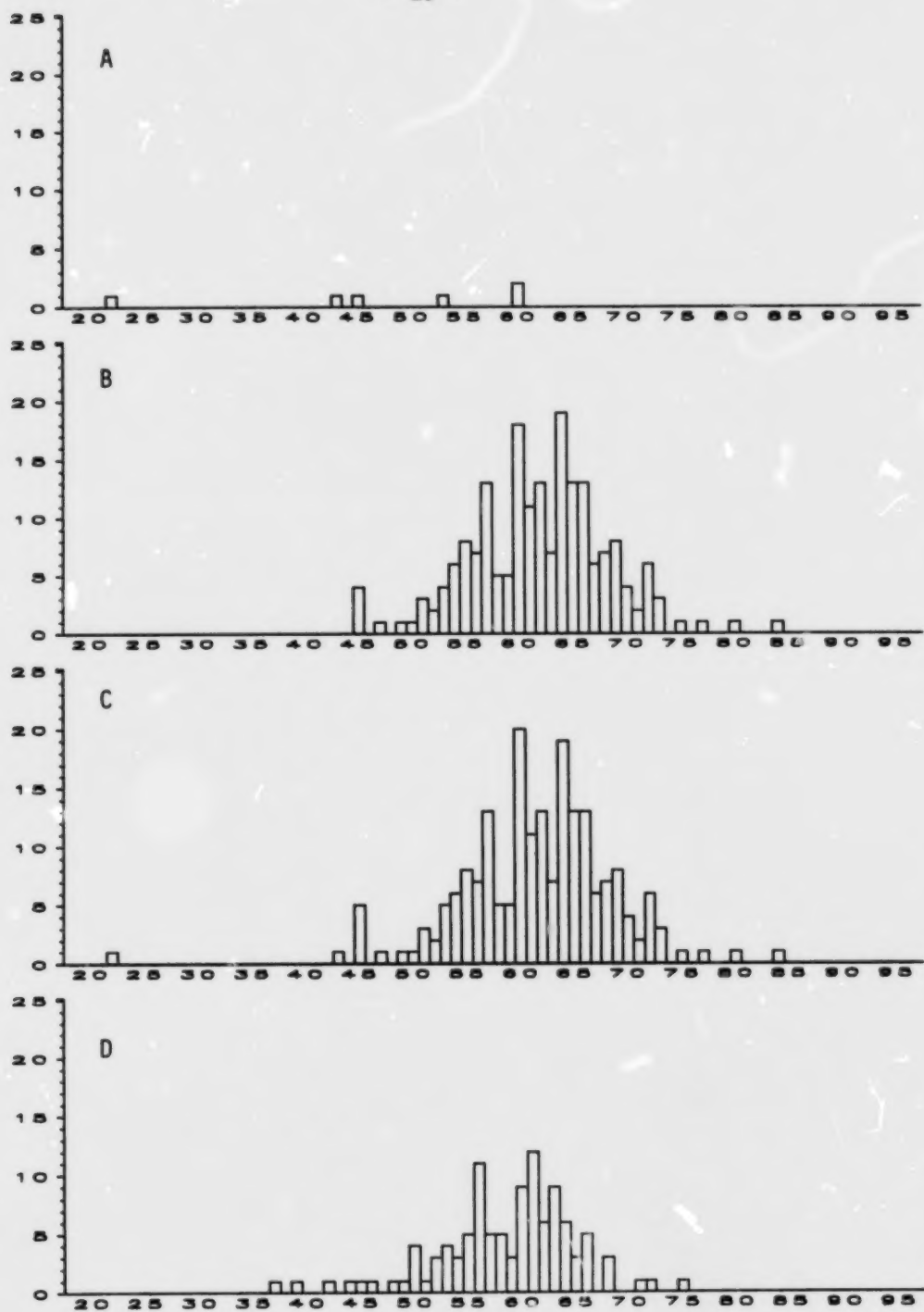
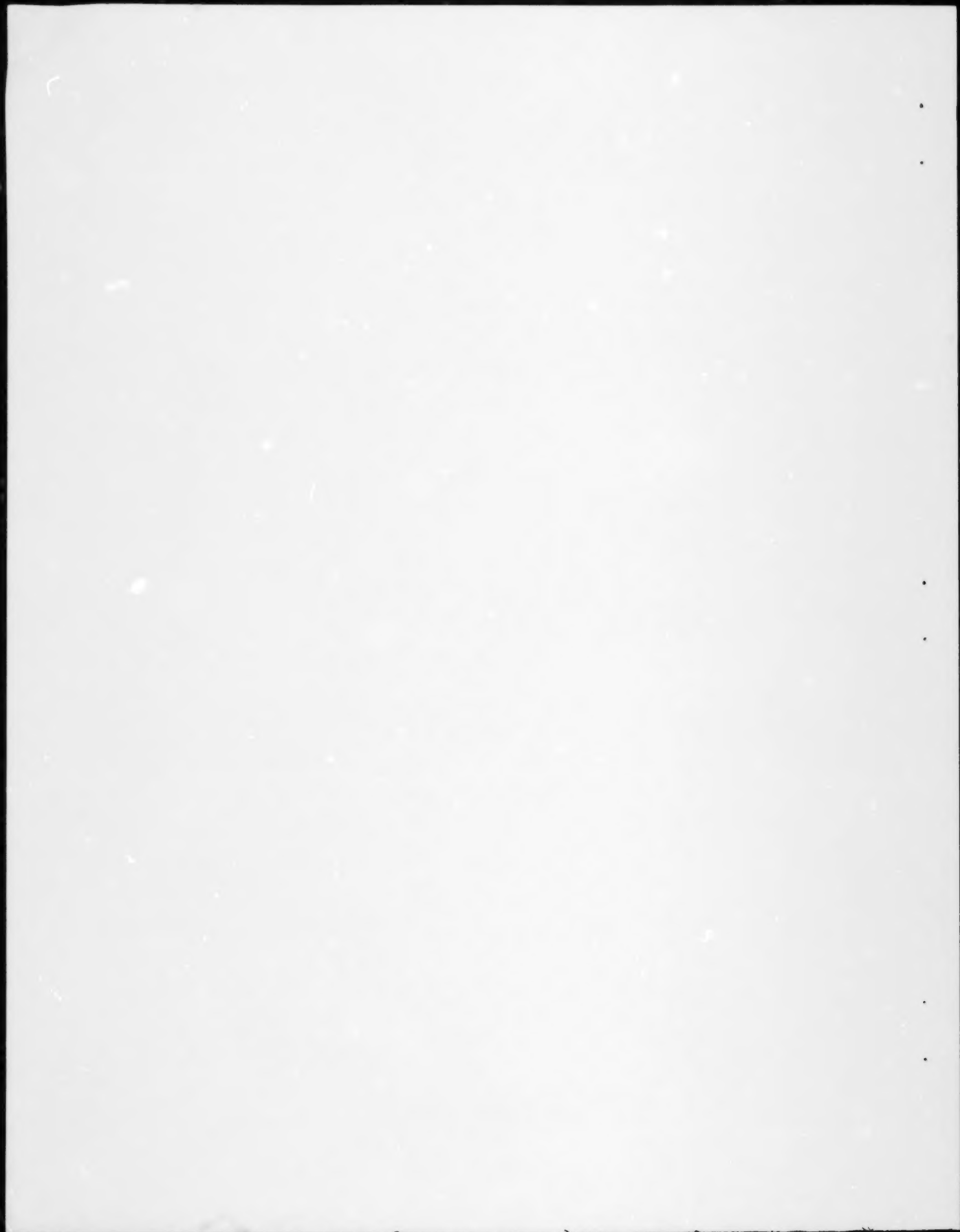


Fig. 8. Length frequency of Pacific cod from Reef Island A) immature females, N=6; B) mature females, N=194; C) all females, N=200; D) males, N=108.



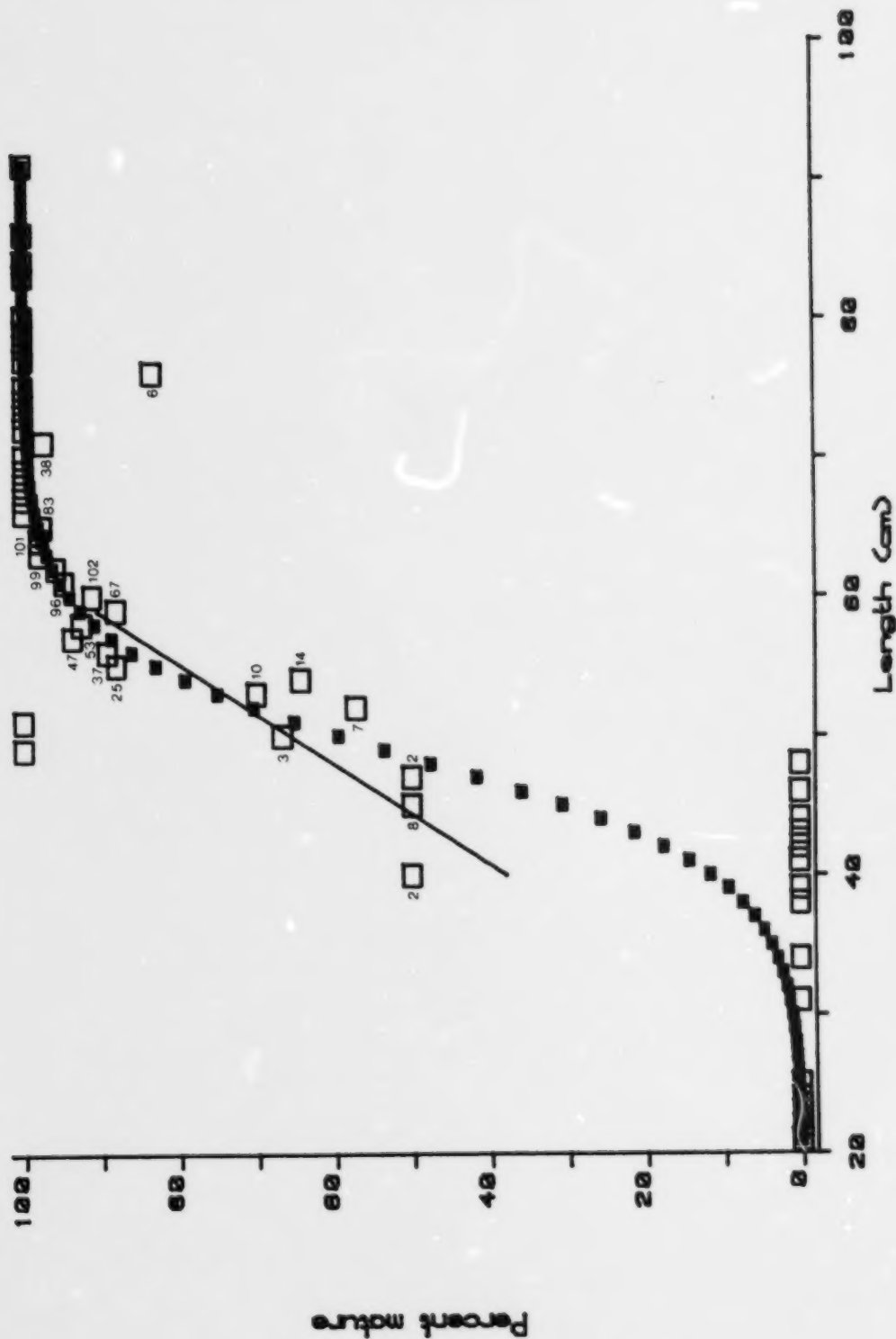
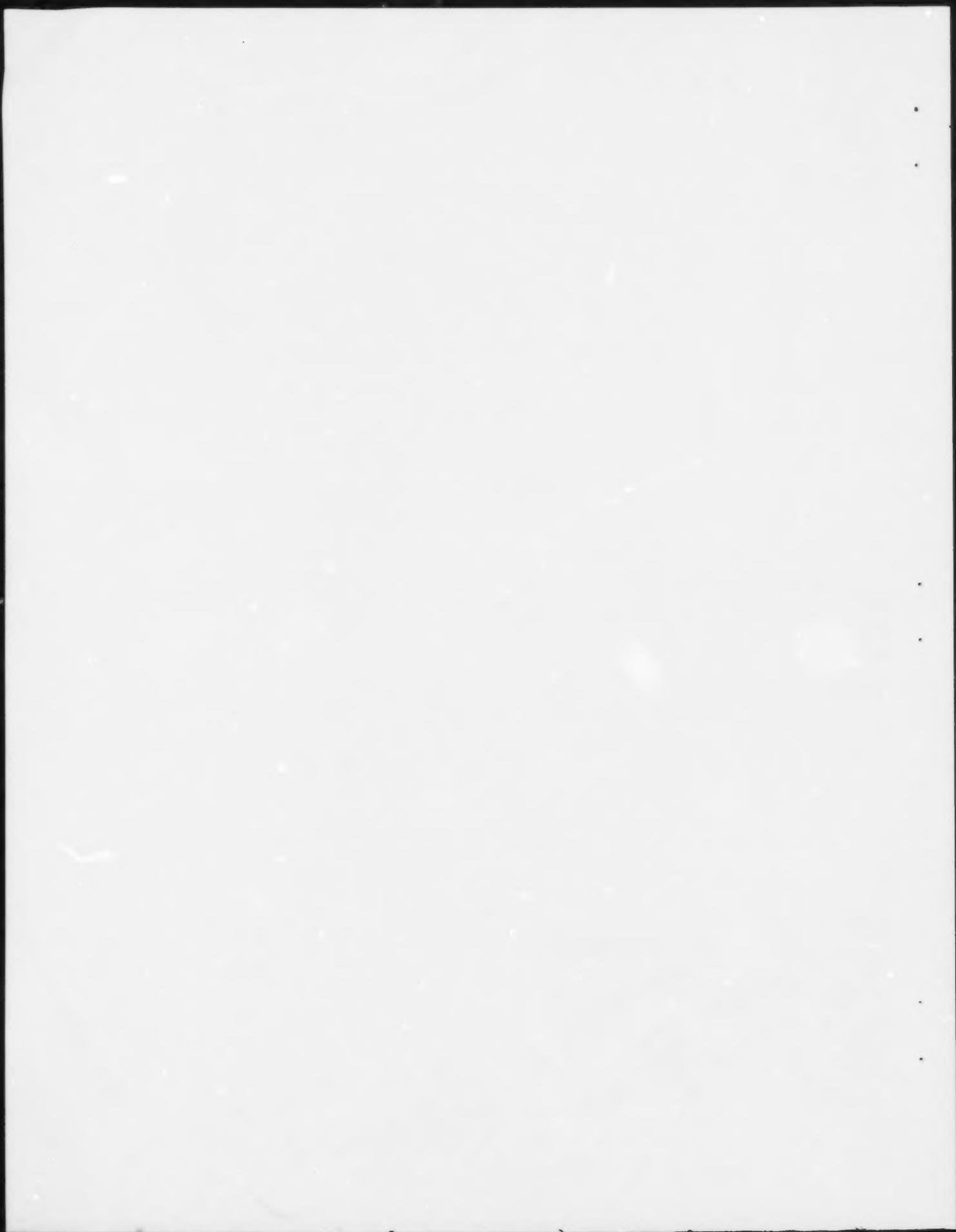


Fig. 9. Percent mature vs. length for Pacific cod, all areas combined. (Open squares = observed, closed squares = values predicted using maximum likelihood method of Welch and Foucher 1988; solid line = linear regression including lengths at which percent mature is between 10 and 90: $Y = 2.42X - 56.3$; $r^2 = 0.727$. Numbers sampled indicated.)



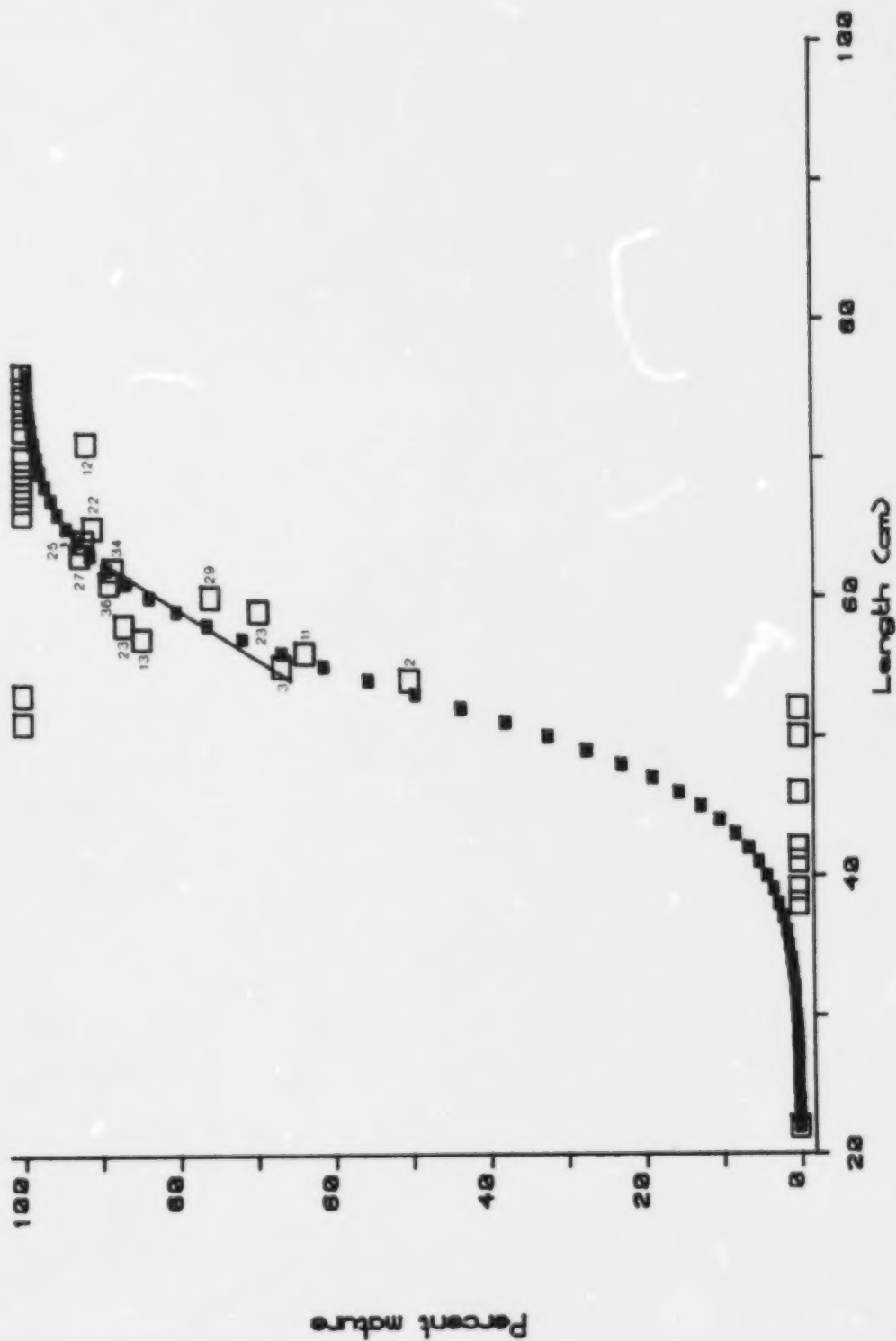


Fig. 10. Percent mature vs. length for Pacific cod, Two Peaks. (Open squares = observed, closed squares = values predicted using maximum likelihood method of Welch and Foucher 1988; solid line = linear regression including lengths at which percent mature is between 10 and 90; $Y = 3.82X - 146$; $r^2 = 0.600$. Numbers sampled indicated.)



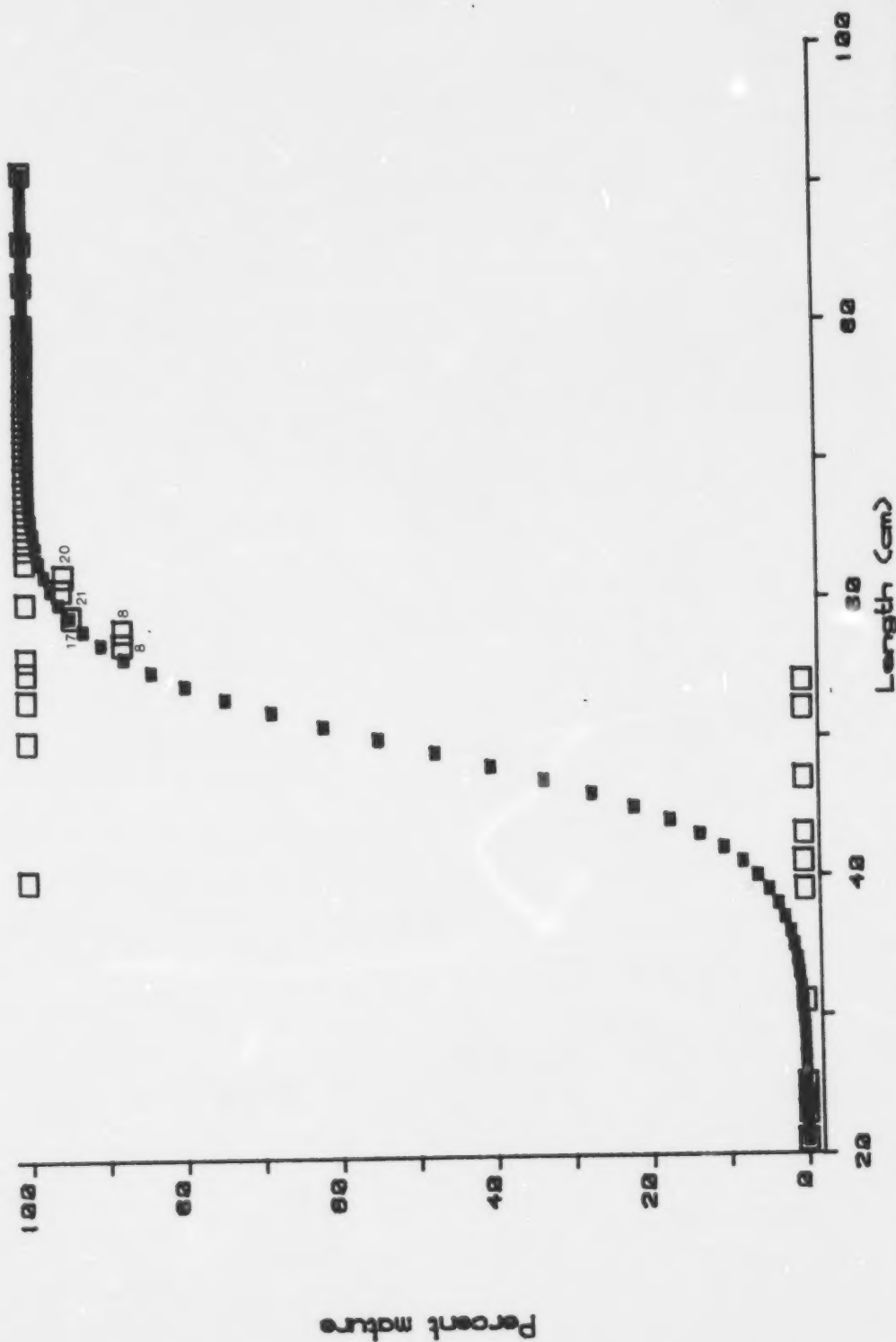


Fig. 11. Percent mature vs. length for Pacific cod, Butterworth. (Open squares = observed, closed squares = values predicted using maximum likelihood method of Welch and Foucher 1988. Numbers sampled indicated.)



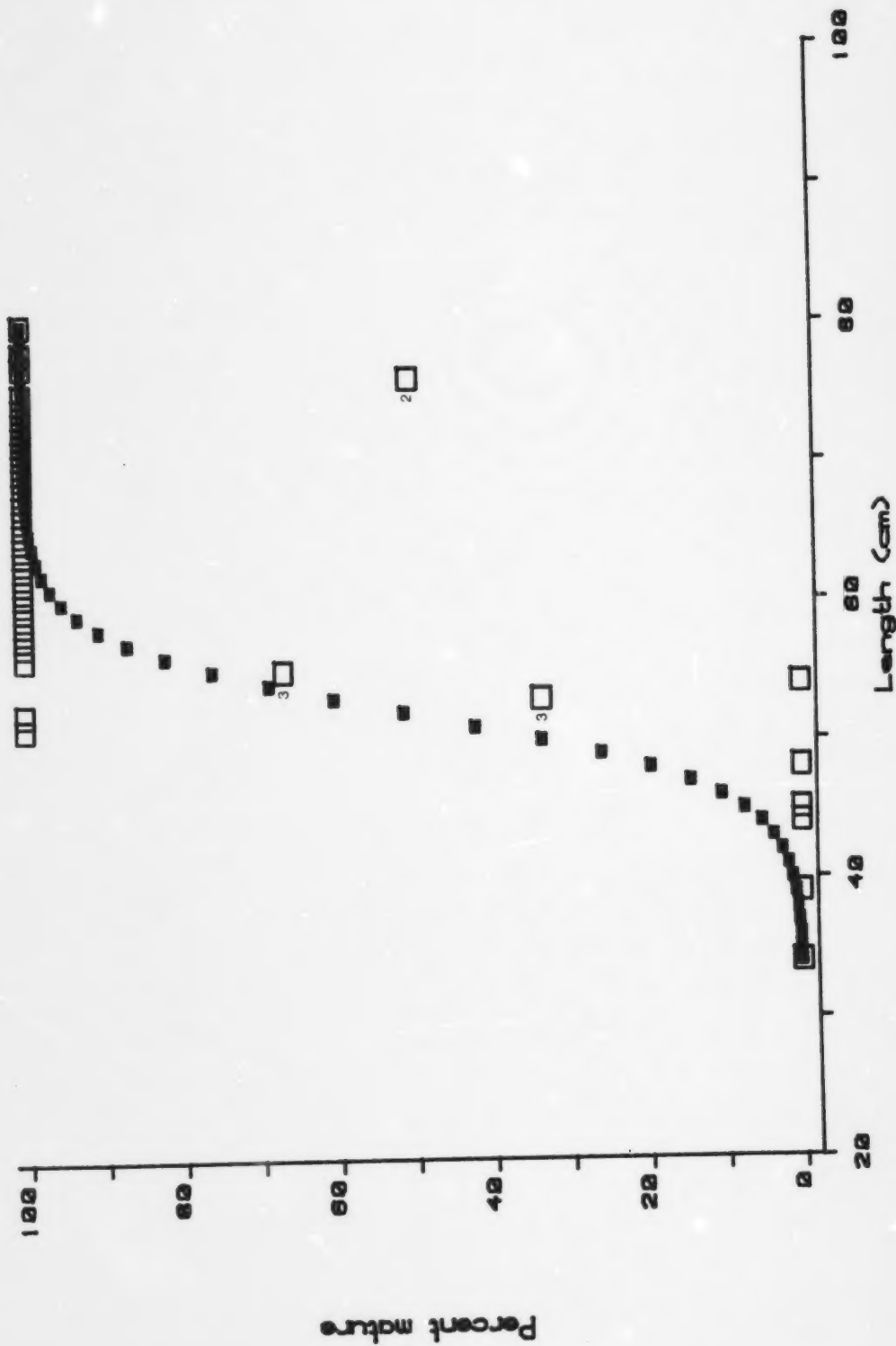


Fig. 12. Percent mature vs. length for Pacific cod, White Rocks. (Open squares = observed, closed squares = values predicted using maximum likelihood method of Welch and Foucher 1988. Numbers sampled indicated.)

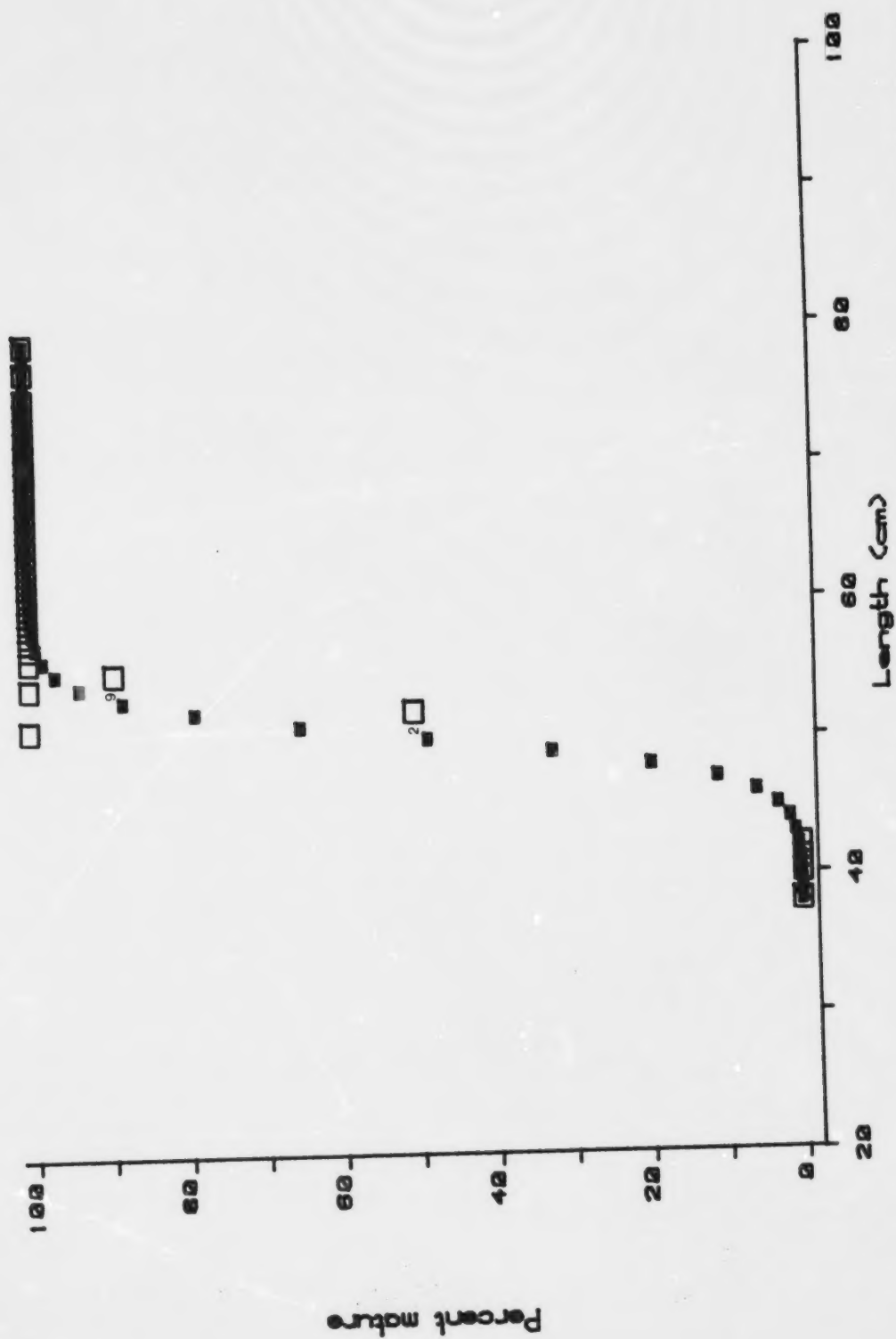


Fig. 13. Percent mature vs. length for Pacific cod, Horseshoe. (Open squares = observed, closed squares = values predicted using maximum likelihood method of Welch and Foucher 1988. Numbers sampled indicated.)



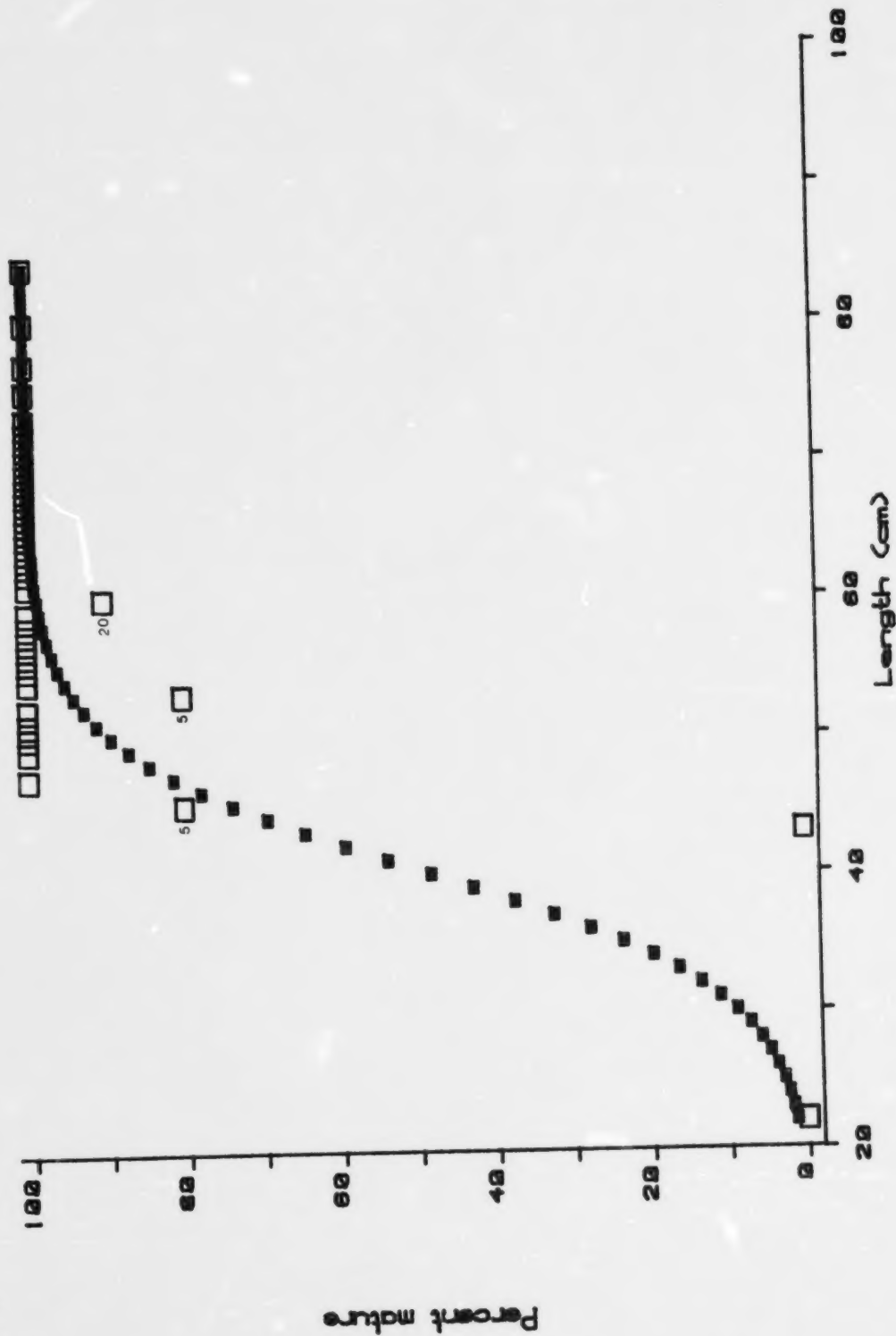


Fig. 14. Percent mature vs. length for Pacific cod, Reef Island. (Open squares = observed, closed squares = values predicted using maximum likelihood method of Welch and Foucher 1988. Numbers sampled indicated.)



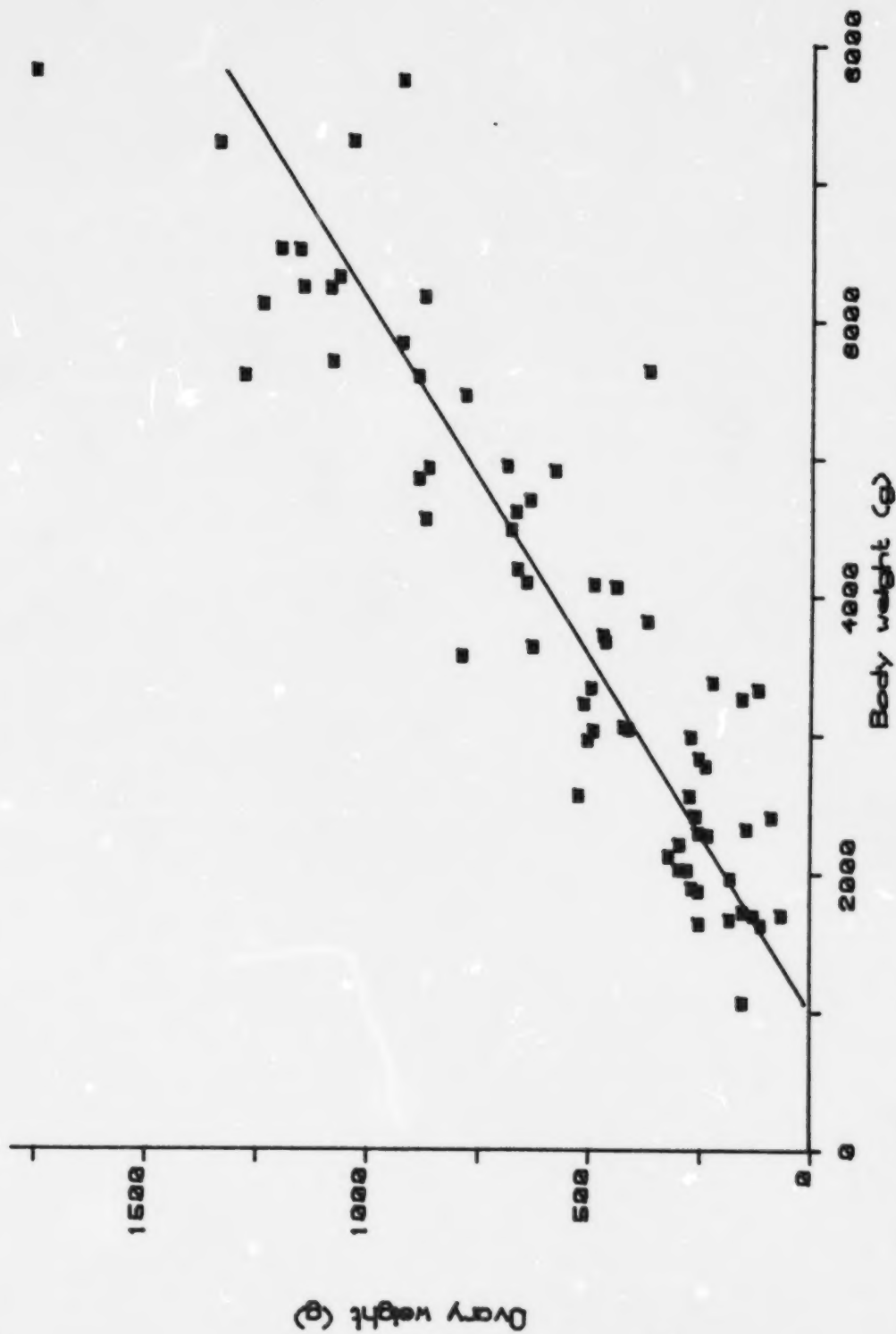
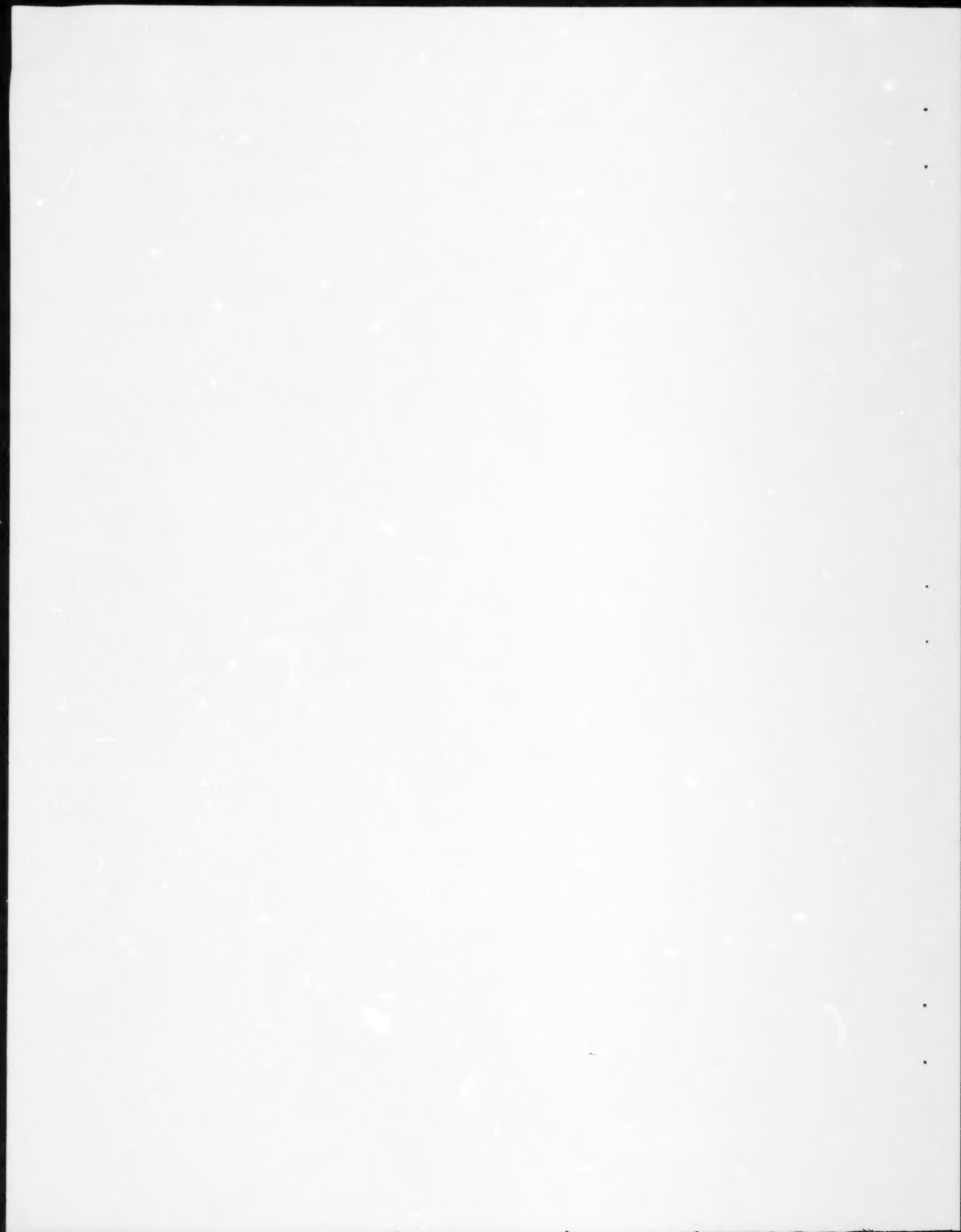


Fig. 15. Pacific cod ovary weight as a function of body weight for Hecate Strait. (Solid line indicates linear regression: $Y = 0.196X - 196$; $r^2 = 0.817$; $n = 67$.)



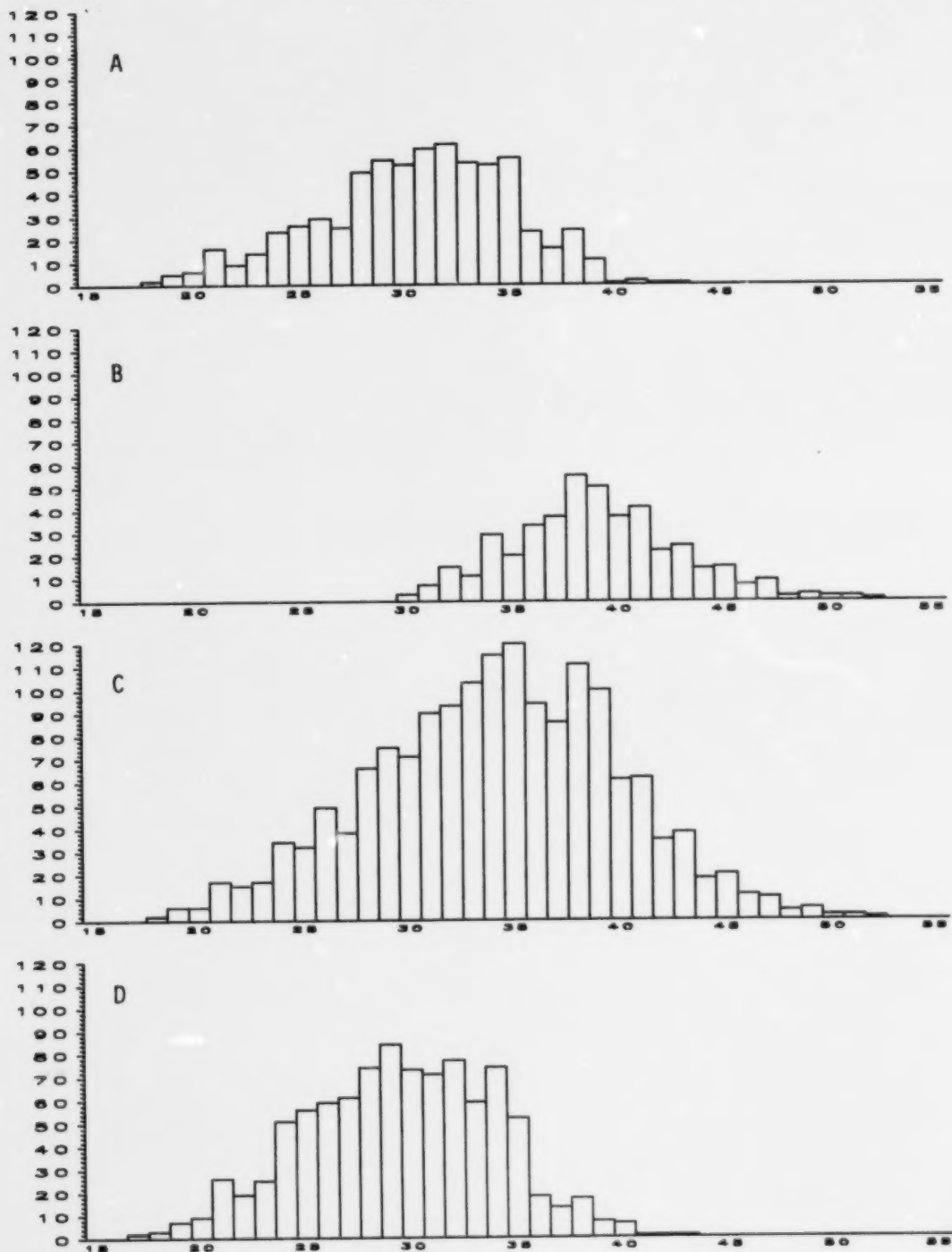


Fig. 16. Length frequency of English sole from all areas combined
 A) immature females, N = 669; B) mature females, N = 440; C) all females,
 N = 1610; D) males, N = 946.



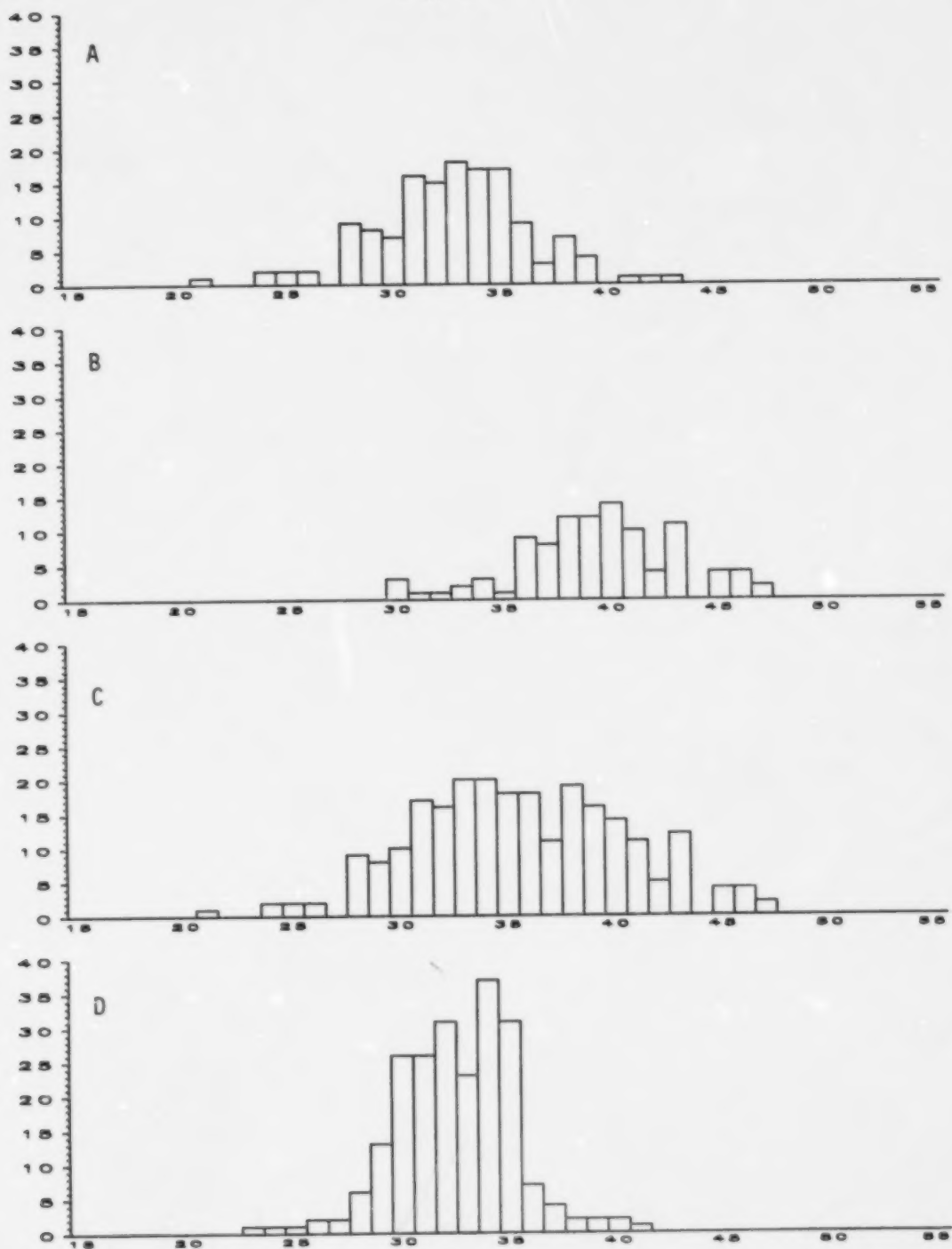


Fig. 17. Length frequency of English sole from Two Peaks A) immature females, N = 149; B) mature females, N = 198; C) all females, N = 609; D) males, N = 114.



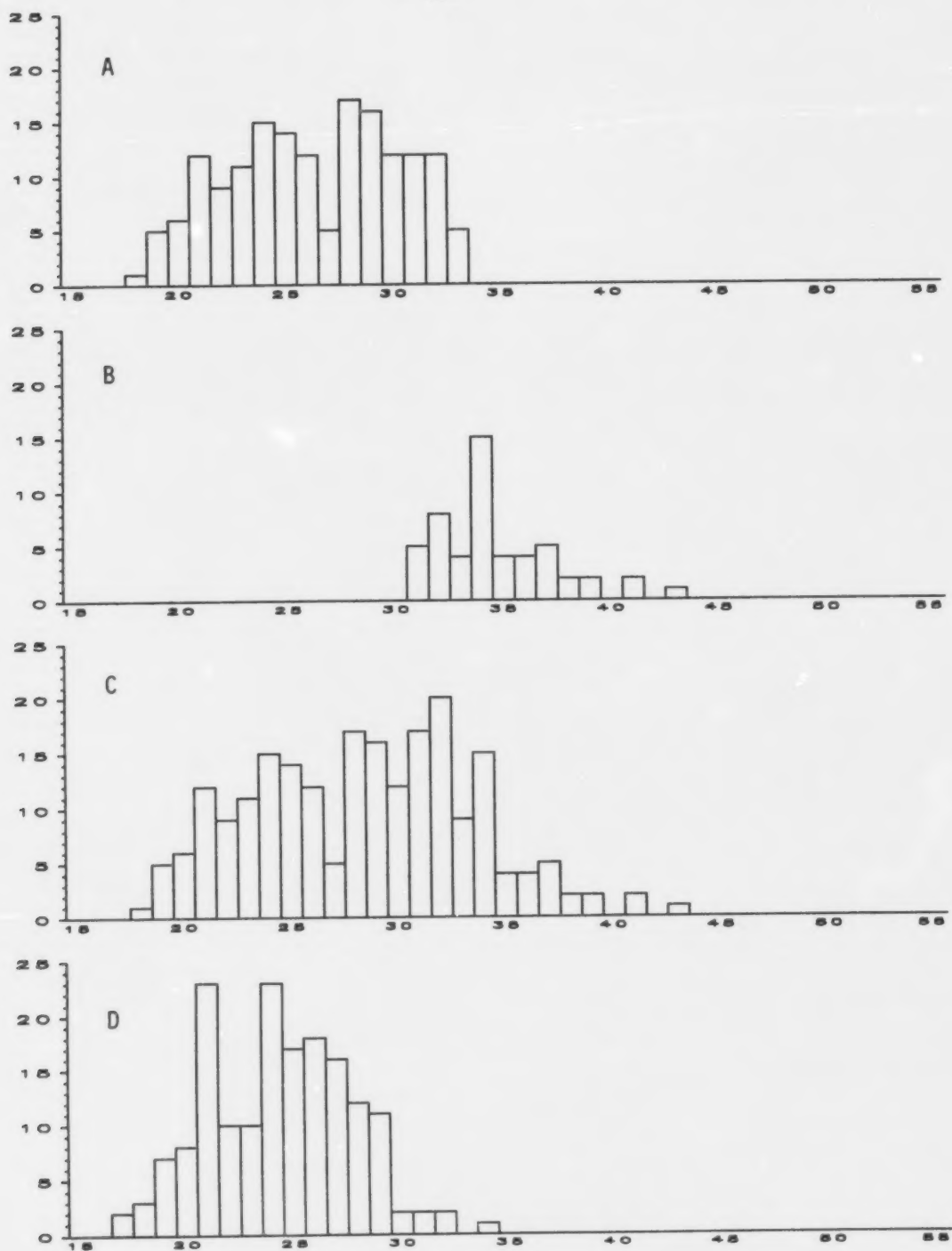


Fig. 18. Length frequency of English sole from Butterworth A) immature females, N = 140; B) mature females, N = 102; C) all females, N = 242; D) males, N = 218.



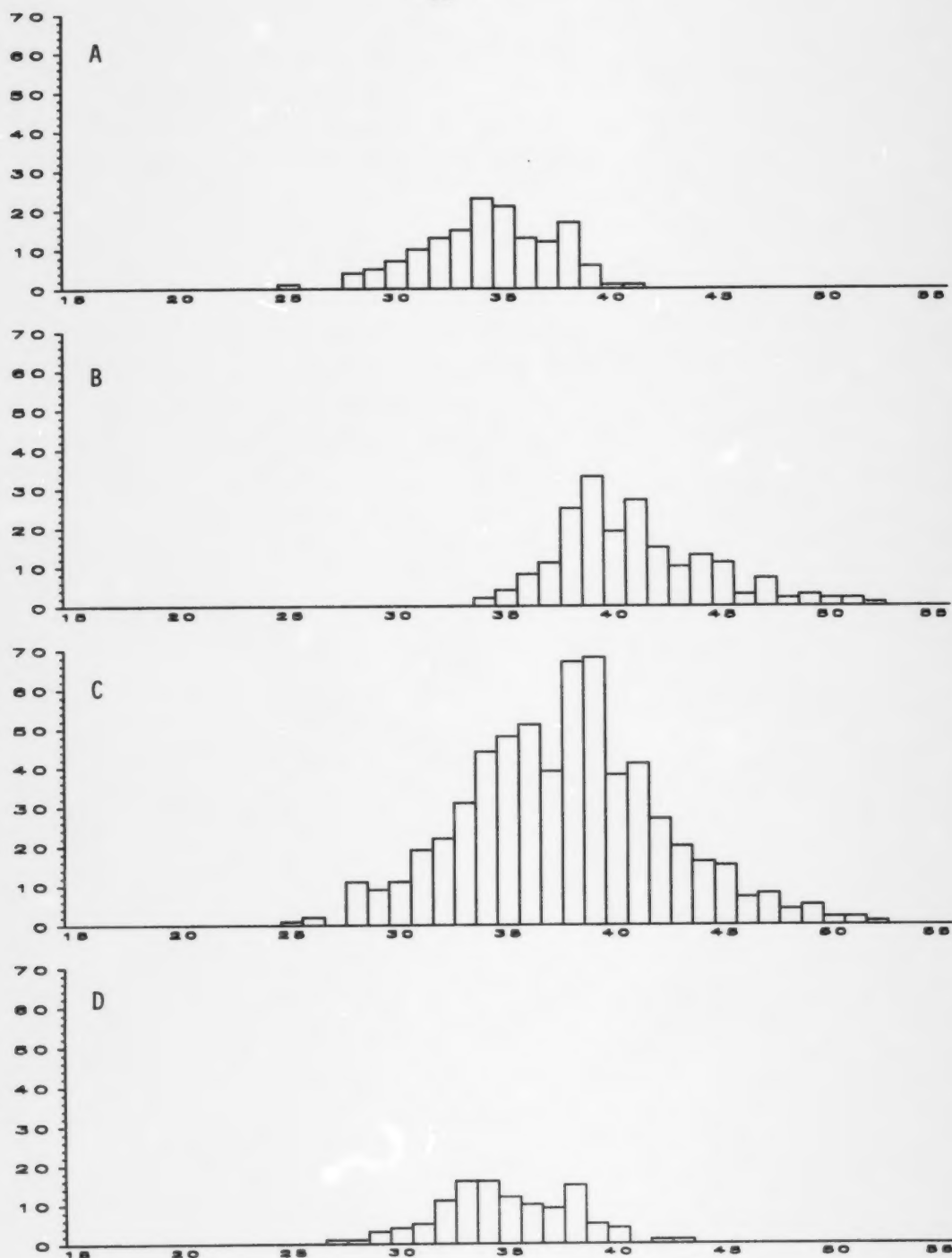


Fig. 19. Length frequency of English sole from White Rocks A) immature females, N = 216; B) mature females, N = 88; C) all females, N = 543; D) males, N = 447.



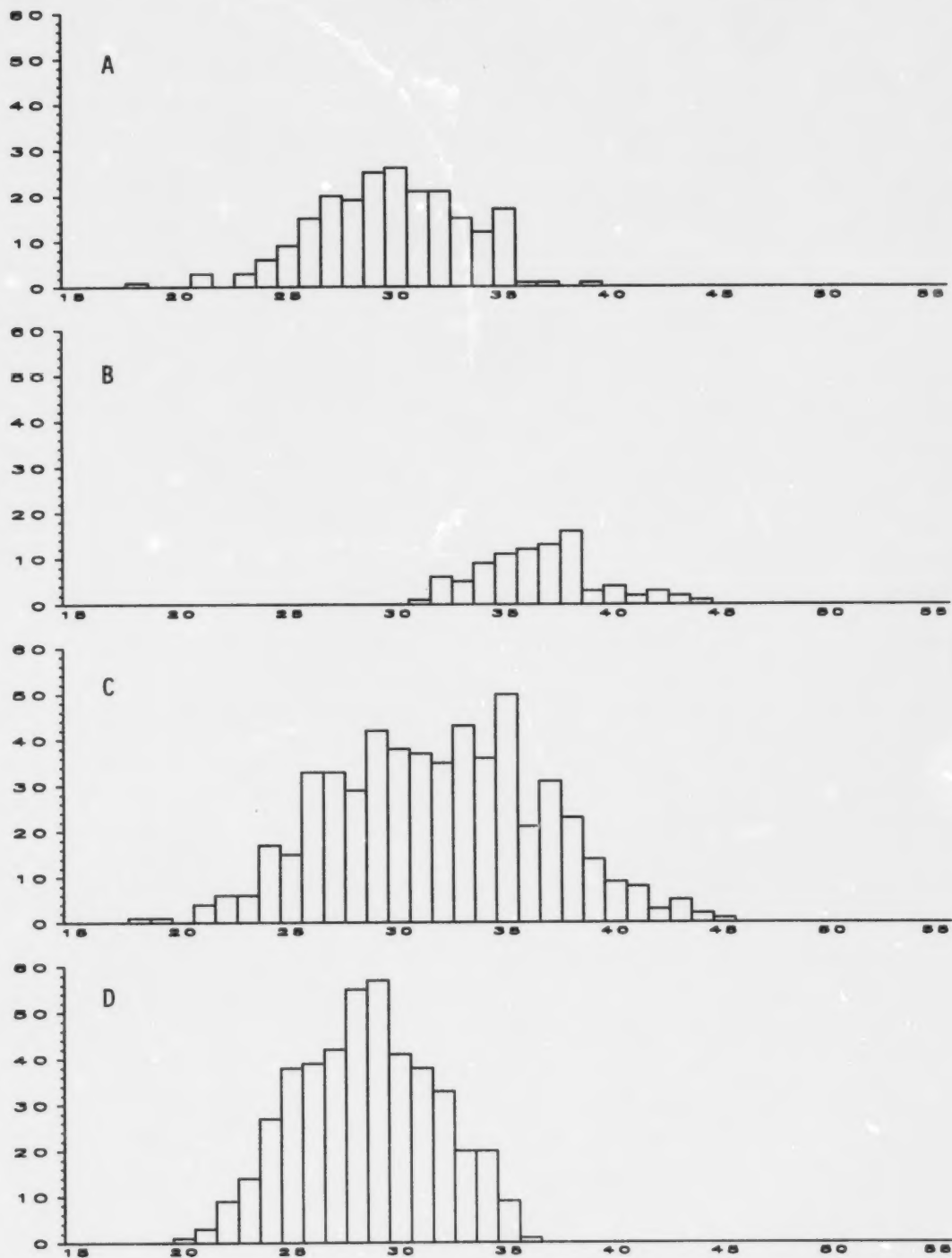


Fig. 20. Length frequency of English sole from Reef Island A) immature females, N = 164; B) mature females, N = 52; C) all females, N = 216; D) males, N = 167.



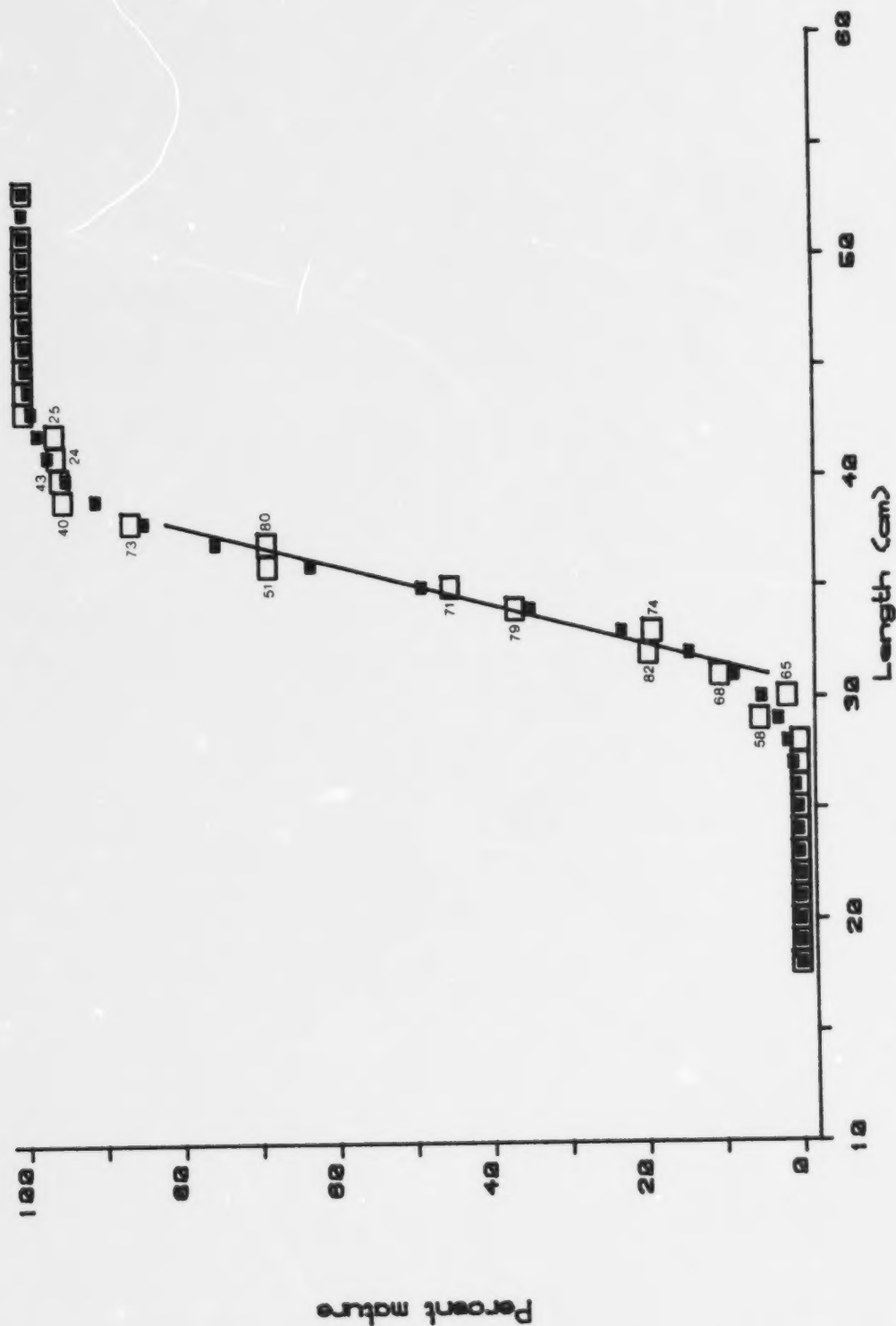


Fig. 21. Percent mature vs. length for English sole, all grounds combined. (Open squares = observed, closed squares = values predicted using maximum likelihood method of Welch and Foucher 1988; solid line = linear regression including lengths at which percent mature is between 10 and 90: $Y = 11.1X - 340$; $r^2 = 0.960$. Numbers sampled indicated.)



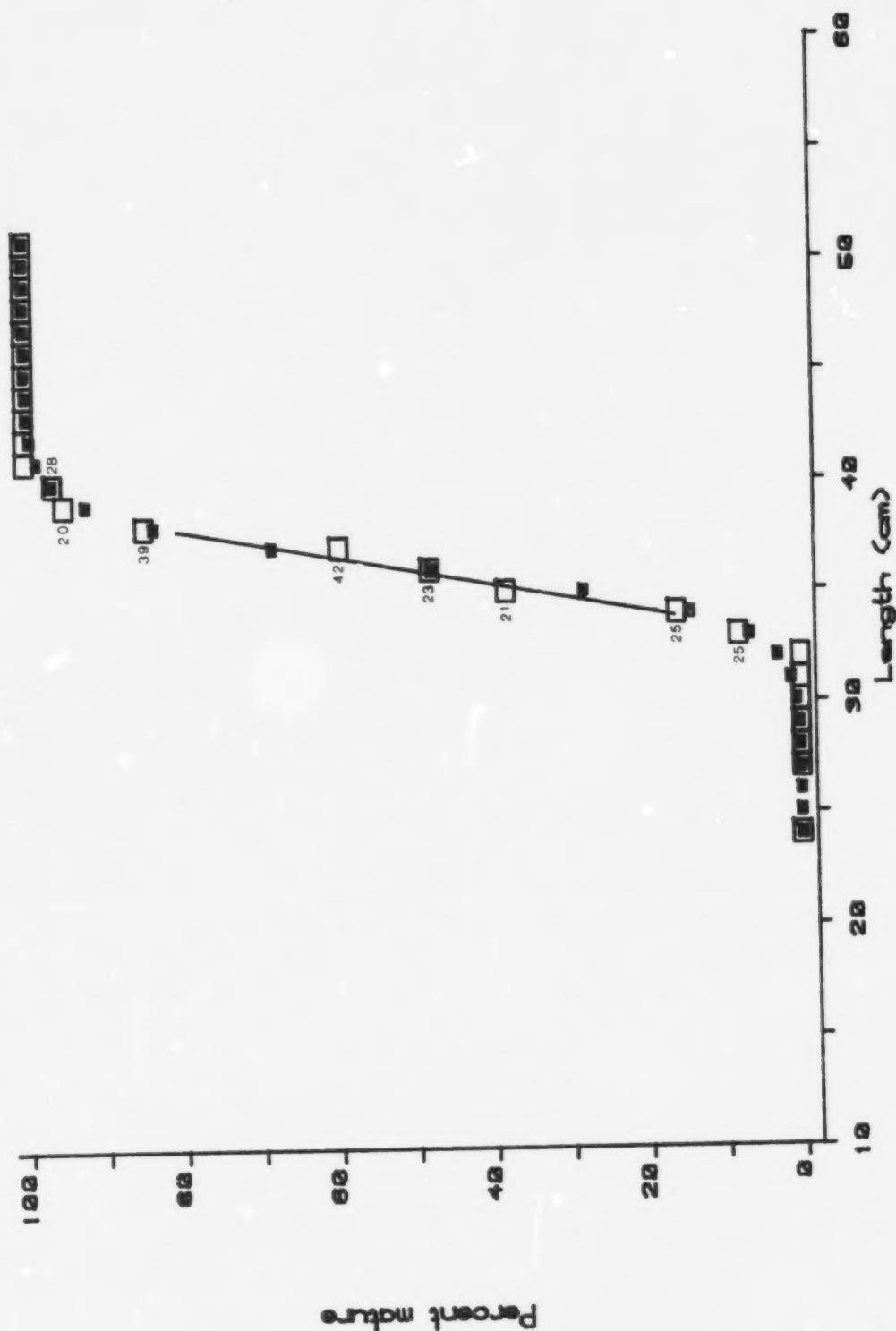


Fig. 22. Percent mature vs. length for English sole, Two Peaks. (Open squares = observed, closed squares = values predicted using maximum likelihood method of Welch and Foucher 1988; solid line = linear regression including lengths at which percent mature is between 10 and 90; $Y = 15.9X - 522$; $r^2 = 0.973$. Numbers sampled indicated.)



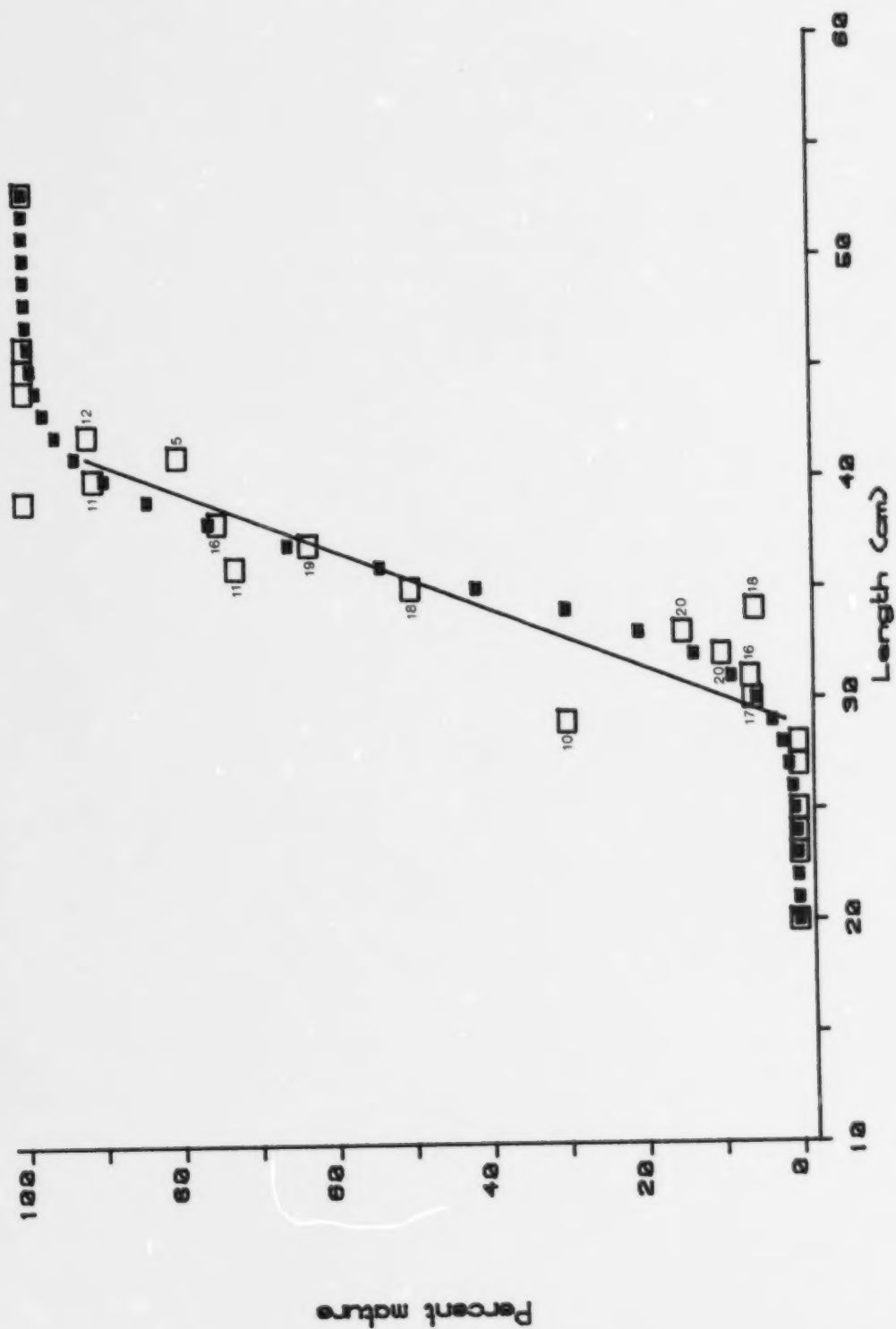


Fig. 23. Percent mature vs. length for English sole, Butterworth. (Open squares = observed, closed squares = values predicted using maximum likelihood method of Welch and Foucher 1988; solid line = linear regression including lengths at which percent mature is between 10 and 90; $Y = 6.22X - 169$; $r^2 = 0.702$. Numbers sampled indicated.)



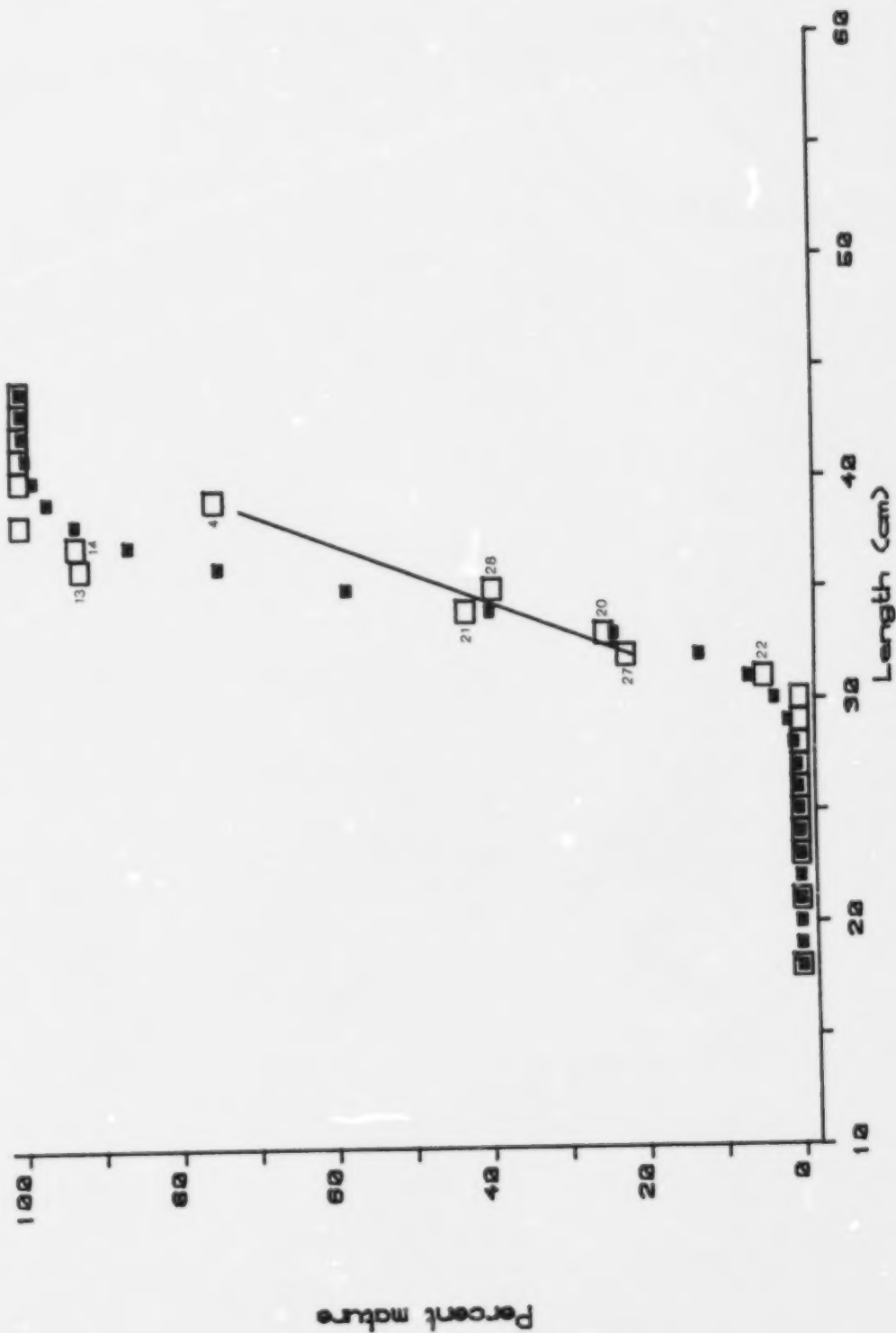


Fig. 24. Percent mature vs. length for English sole, White Rocks. (Open squares = observed, closed squares = values predicted using maximum likelihood method of Welch and Foucher 1988; solid line = linear regression including lengths at which percent mature is between 10 and 90; $Y = 7.61X - 222$; $r^2 = 0.955$. Numbers sampled indicated.)



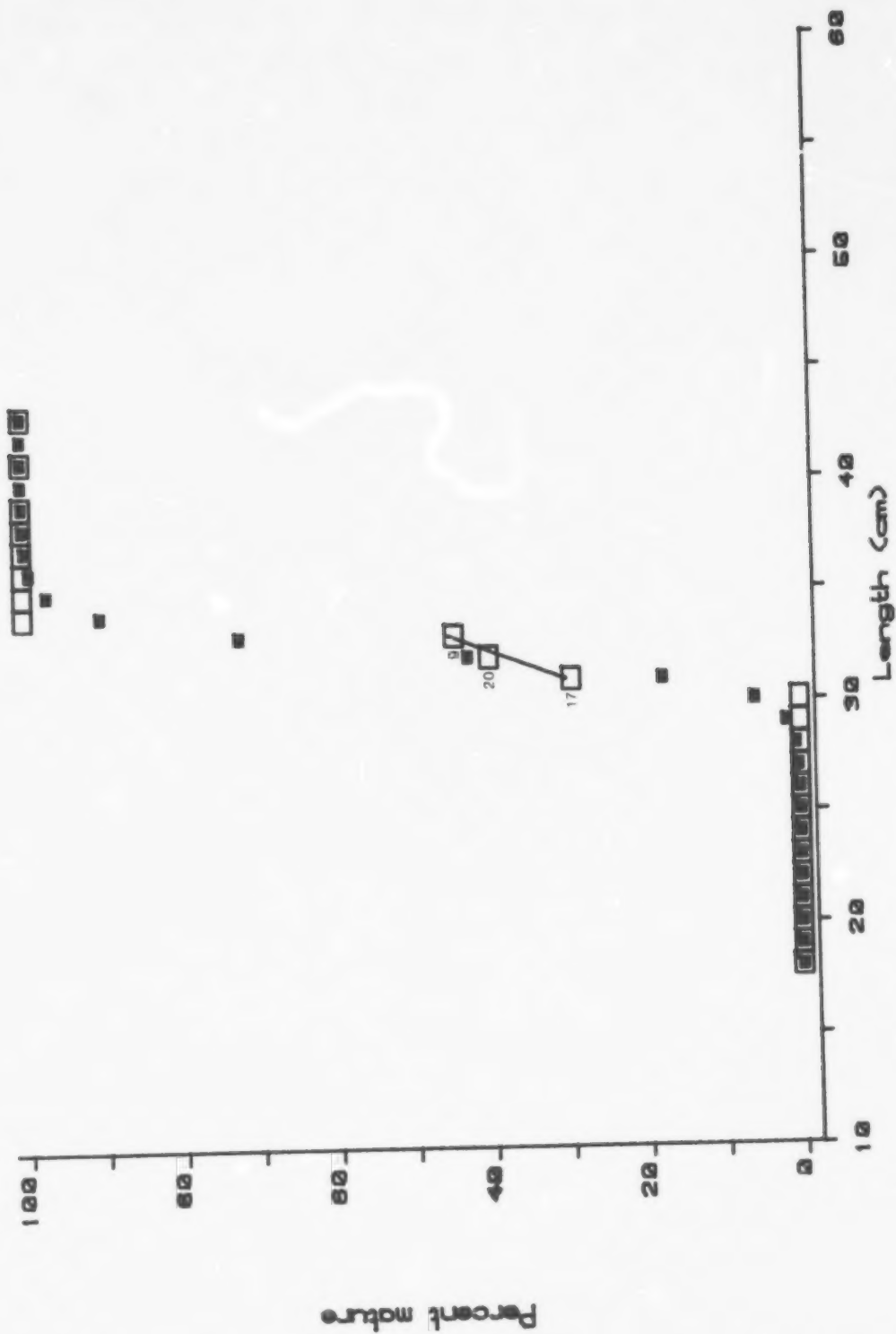


Fig. 25. Percent mature vs. length for English sole, Reef Island. (Open squares = observed, closed squares = values predicted using maximum likelihood method of Welch and Foucher 1988; solid line = linear regression including lengths at which percent mature is between 10 and 90: $Y = 7.52X - 203$; $r^2 = 0.947$. Numbers sampled indicated.)



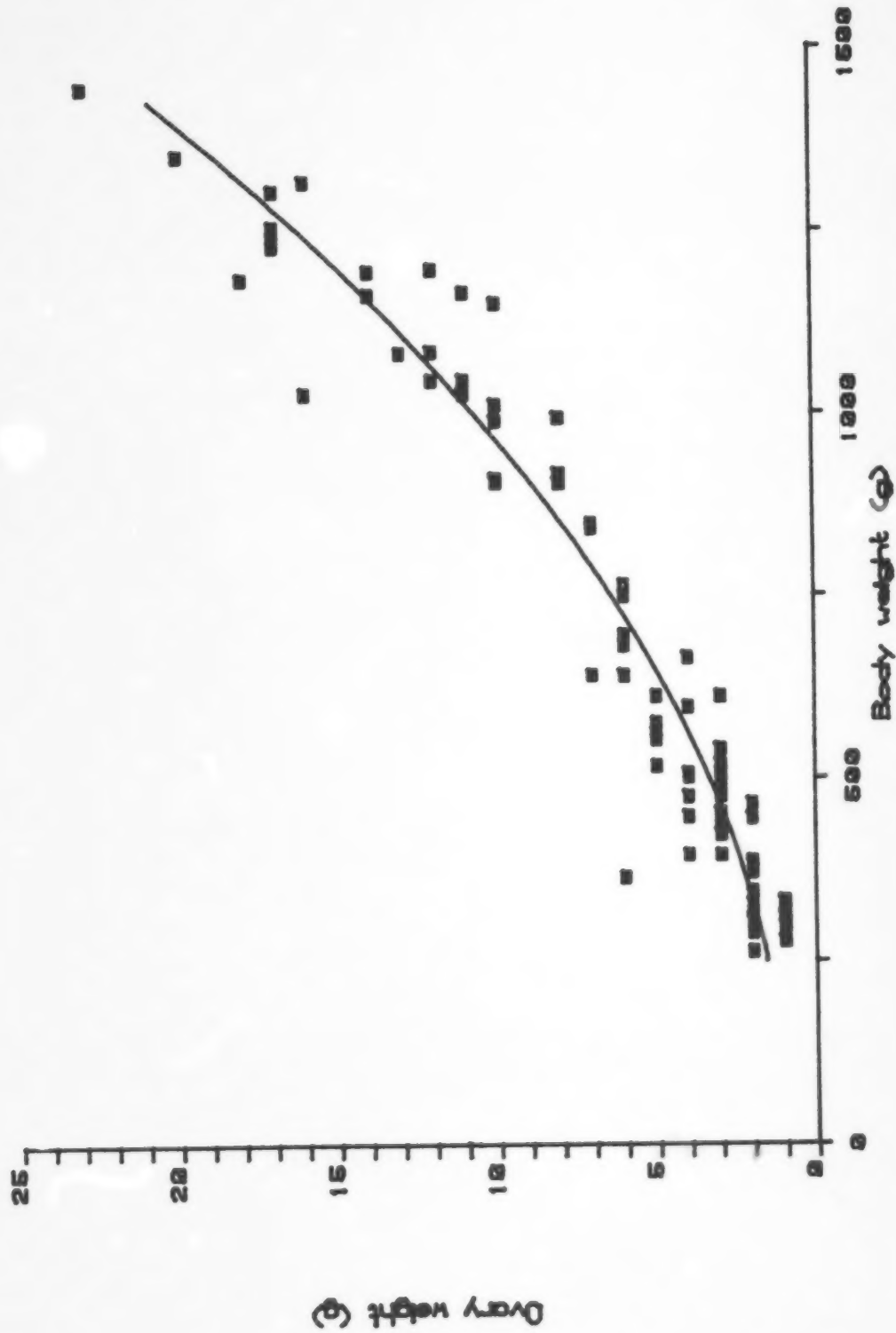


Fig. 26. English sole ovary weight as a function of body weight for White Rocks Ground. (Solid line indicates linear regression: $Y = 0.0151X - 3.72$; $r^2 = 0.911$; $n = 80$.)



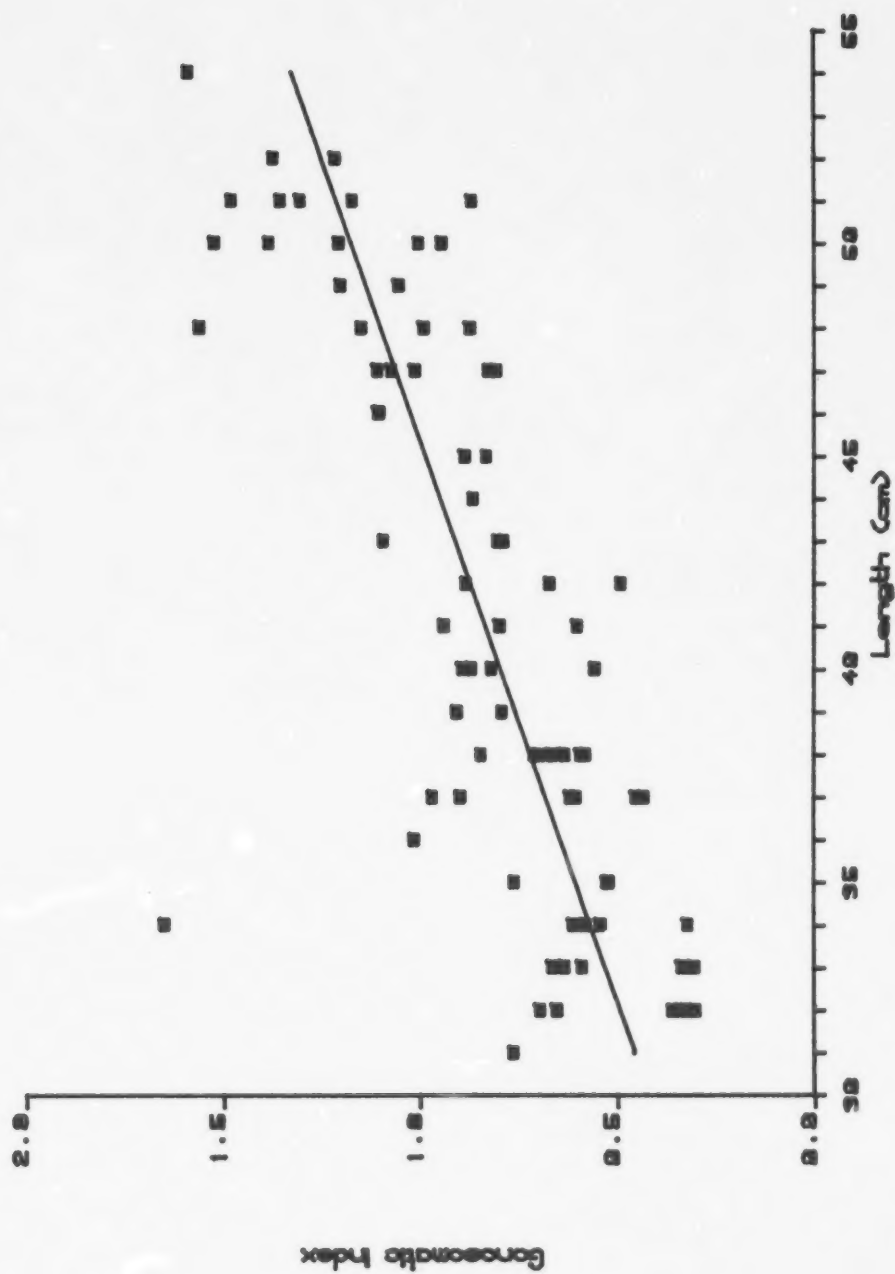


Fig. 27. English sole gonosomatic index (%) as a function of length. ($Y = -0.727 + 0.0381X$; $r^2 = 0.584$; $n = 80$).



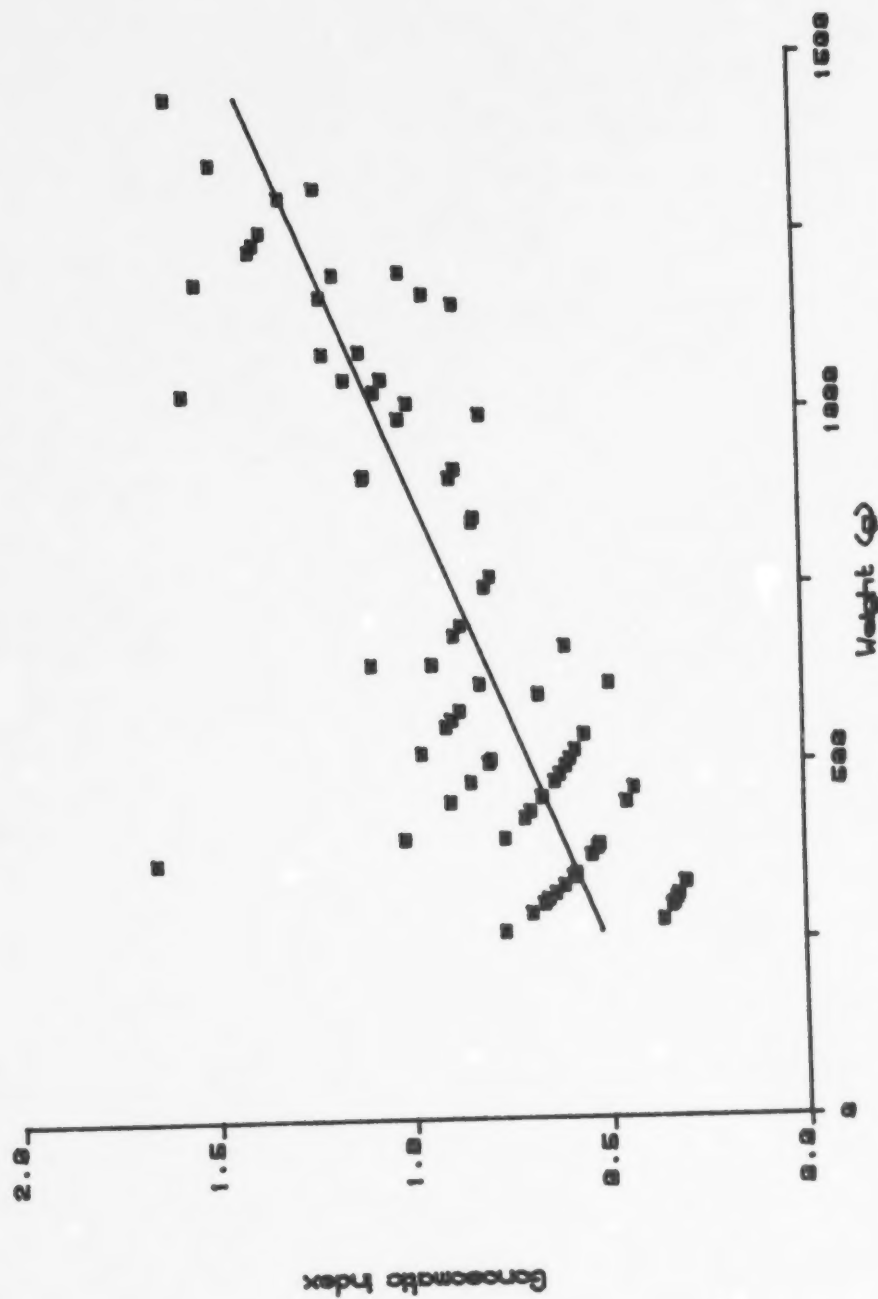
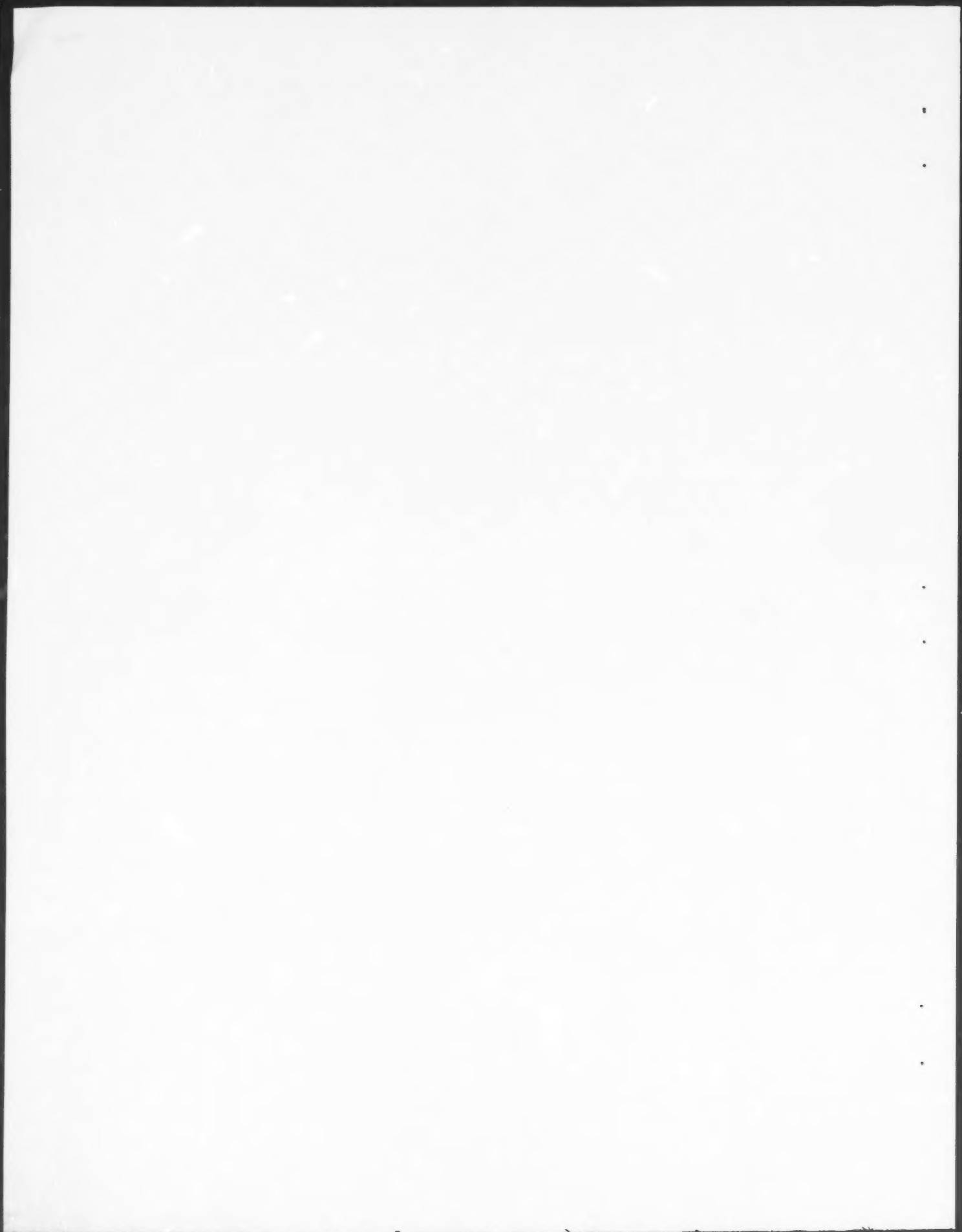


Fig. 28. English sole gonosomatic index (%) as a function of body weight. ($Y = 0.319 + 0.000759X$; $r^2 = 0.613$; $n = 80$).



Appendix Table 1. Bridge log for MV BLUE WATERS cruise to Hecate Strait, January 30-February 11, 1989.

Haul number	1		2	
Ground	White Rocks		White Rocks	
Date (1989)	Feb. 4		Feb. 4	
Depth interval (FA)	60		50	
Duration (h)	0.53		0.50	
Direction (Deg. true)	150		186	
	Start	Stop	Start	Stop
Time (PST)	8:50	9:22	10:55	11:25
Lat. (deg,min)	53 44.4	53 43.0	53 39.7	53 38.1
Long. (deg,min)	130 46.8	130 45.9	130 45.8	130 46.1
LORAN C	11981.6	11996.5	12020.9	12032.7
LORAN C	30525	30522.2	30515.3	30510.9
Depth (Fa)	61	60	54	54
Target species catch (kg)				
English sole	539		109	
Pacific cod	99		-	

Haul number	3		4	
Ground	White Rocks		White Rocks	
Date (1989)	Feb. 5		Feb. 5	
Depth interval (FA)	50		70	
Duration (h)	0.57		0.50	
Direction (Deg. true)	40		5	
	Start	Stop	Start	Stop
Time (PST)	8:53	9:27	11:15	11:45
Lat. (deg,min)	53 27.2	53 28.7	53 36.0	53 38
Long. (deg,min)	130 54.8	130 52.4	130 47.4	130 46.9
LORAN C	12080.6	12078.6	12043.1	12030.4
LORAN C	41596.2	41604.5	41636.4	41644
Depth (Fa)	57	57	72	75
Target species catch (kg)				
English sole	200		-	
Pacific cod	5		1014	

Appendix Table 1 (cont'd) Bridge log for MV BLUE WATERS cruise to Hecate Strait, January 30-February 11, 1989.

Haul number	5		6	
Ground	White Rocks		Reef Island	
Date (1989)	Feb. 5		Feb. 6	
Depth interval (FA)	70		60	
Duration (h)	0.50		0.50	
Direction (Deg. true)	185		20	
	Start	Stop	Start	Stop
Time (PST)	12:20	12:50	8:21	8:51
Lat. (deg,min)	53 38.7	53 37.1	52 53.7	52 54.9
Long. (deg,min)	130 46.5	130 47.1	131 19	131 16.7
LORAN C	12026.4	12036.5	12228.5	12229.3
LORAN C	41647.1	41640.3	30377.5	30382.2
Depth (Fa)	73	76	65	58
Target species catch (kg)				
English sole	-		28	
Pacific cod	417		219	

Haul number	7		8	
Ground	Reef Island		Horseshoe	
Date (1989)	Feb. 6		Feb. 6	
Depth interval (FA)	60		70	
Duration (h)	0.50		0.50	
Direction (Deg. true)	225		120	
	Start	Stop	Start	Stop
Time (PST)	9:28	9:58	14:56	15:26
Lat. (deg,min)	52 54.6	52 53.7	52 59.2	52 58.2
Long. (deg,min)	131 17.3	131 19.4	130 39.6	130 37
LORAN C	12229.2	12227.2	12345.7	12364
LORAN C	30381	30377.2	30417.6	30416.6
Depth (Fa)	60	60	71	69
Target species catch (kg)				
English sole	39		-	
Pacific cod	602		529	

Appendix Table 1 (cont'd) Bridge log for MV BLUE WATERS cruise to Hecate Strait, January 30-February 11, 1989.

Haul number	9		10	
Ground	Horseshoe		Two Peaks	
Date (1989)	Feb. 6		Feb. 7	
Depth interval (FA)	60		60	
Duration (h)	0.50		0.50	
Direction (Deg. true)	290		30	
	Start	Stop	Start	Stop
Time (PST)	15:55	16:25	7:25	7:55
Lat. (deg,min)	52 58.0	52 58.4	54 19.1	54 20.4
Long. (deg,min)	130 36.5	130 37.9	131 19.9	131 18.3
LORAN C	12367.5	12358.8	11577	11571.5
LORAN C	30416.6	30416.7	41730	41736.3
Depth (Fa)	62	60	65	63
Target species catch (kg)				
English sole	-		297	
Pacific cod	2473		63	
Haul number	11		12	
Ground	Two Peaks		Two Peaks	
Date (1989)	Feb. 7		Feb. 7	
Depth interval (FA)	70		60	
Duration (h)	0.50		0.50	
Direction (Deg. true)	220		60	
	Start	Stop	Start	Stop
Time (PST)	8:27	8:57	10:45	11:15
Lat. (deg,min)	54 20.9	54 19.6	54 17.8	54 18.2
Long. (deg,min)	131 18.7	131 19.8	131 28.2	131 24.5
LORAN C	11566	11573.7	11561.7	11570.5
LORAN C	41737.4	41731.7	41715.8	41721.5
Depth (Fa)	69	70	62	56
Target species catch (kg)				
English sole	132		-	
Pacific cod	24		738	

Appendix Table 1 (cont'd) Bridge log for MV BLUE WATERS cruise to Hecate Strait, January 30-February 11, 1989.

Haul number	13		14	
Ground	Two Peaks		Butterworth	
Date (1989)	Feb. 7		Feb. 8	
Depth interval (FA)	50		50	
Duration (h)	0.50		0.50	
Direction (Deg. true)	60		140	
	Start	Stop	Start	Stop
Time (PST)	11:45	12:15	8:15	8:45
Lat. (deg,min)	54 18.4	54 18.5	54 18.4	54 17.0
Long. (deg,min)	131 22.5	131 18.8	131 06.7	131 05.5
LORAN C	11574.8	11586.1	11626.9	11644.9
LORAN C	41724.7	41730	41746.5	41743.6
Depth (Fa)	59	54	50	47
Target species catch (kg)				
English sole	-		1729	
Pacific cod	885		40	
Haul number	15			
Ground	Butterworth			
Date (1989)	Feb. 8			
Depth interval (FA)	40			
Duration (h)	0.50			
Direction (Deg. true)	180			
	Start	Stop		
Time (PST)	9:30	10:00		
Lat. (deg,min)	54 15.8	54 14.0		
Long. (deg,min)	131 05	131 05.6		
LORAN C	11665.8	11678.3		
LORAN C	41737.7	41731.7		
Depth (Fa)	40	38		
Target species catch (kg)				
English sole	-			
Pacific cod	1092			

Appendix Table 2. Length frequency of Pacific cod sampled, by haul, by sex, and by maturity stage (females only) during the cruise of the FV BLUE WATERS to Hecate Strait, January 30 - February 11, 1989.
HAUL 4.

Length (cm)	Females							Total	Males	Total
	1	2	3	4	5	6	7			
25	-	-	-	-	-	-	-	-	1	1
26	-	-	-	-	-	-	-	-	0	0
27	-	-	-	-	-	-	-	-	1	1
28	-	-	-	-	-	-	-	-	0	0
29	-	-	-	-	-	-	-	-	0	0
30	-	-	-	-	-	-	-	-	0	0
31	-	-	-	-	-	-	-	-	0	0
32	-	-	-	-	-	-	-	-	0	0
33	-	-	-	-	-	-	-	-	0	0
34	-	1	-	-	-	-	-	1	0	1
35	-	0	-	-	-	-	-	0	0	0
36	-	0	-	-	-	-	-	0	0	0
37	-	0	-	-	-	-	-	0	0	0
38	-	0	-	-	-	-	-	0	1	1
39	-	2	-	-	-	-	-	2	0	2
40	-	0	-	-	-	-	-	0	0	0
41	-	0	-	-	-	-	-	0	1	1
42	-	0	-	-	-	-	-	0	1	1
43	-	0	-	-	-	-	-	0	0	0
44	-	1	-	-	-	-	-	1	1	2
45	-	3	-	-	-	-	-	3	4	7
46	-	0	-	-	-	-	-	0	0	0
47	-	0	-	-	-	-	-	0	1	1
48	-	2	-	-	-	-	-	2	5	7
49	-	0	-	-	-	-	-	0	3	3
50	-	0	-	-	-	-	-	0	4	4
51	-	0	-	1	-	-	-	1	1	2
52	-	0	1	0	-	-	-	1	4	5
53	-	2	0	1	-	-	-	3	1	4
54	-	2	0	0	-	-	-	2	4	6
55	-	1	1	1	-	-	-	3	2	5
56	-	-	0	1	-	-	-	1	6	7
57	-	-	0	2	-	-	-	2	4	6
58	-	-	0	2	-	1	1	4	7	11
59	-	-	2	6	-	0	0	8	8	16
60	-	-	2	8	-	1	0	11	14	25
61	-	-	0	6	-	0	0	6	18	24
62	-	-	3	12	-	0	0	15	14	29
63	-	-	0	9	-	1	1	11	11	22
64	-	-	1	12	-	0	-	13	13	26
65	-	-	1	8	-	0	-	9	12	21
66	-	-	-	8	-	2	-	10	10	20
67	-	-	-	13	-	0	-	13	4	17
68	-	-	-	3	-	0	-	3	5	8
69	-	-	-	3	-	0	-	3	5	8
70	-	-	-	10	-	1	-	11	0	11
71	-	-	-	7	-	-	-	7	1	8
72	-	-	-	1	-	-	-	1	3	4
73	-	-	-	3	-	-	-	3	3	6
74	-	-	-	1	-	-	-	1	1	2
75	-	-	-	2	-	-	-	2	1	3
76	1	-	-	1	-	-	-	2	1	3
77	-	-	-	1	-	-	-	1	-	1
78	-	-	-	1	-	-	-	1	-	1
79	-	-	-	0	-	-	-	0	-	0
80	-	-	-	1	-	-	-	1	-	1
Total	1	14	11	124	0	6	2	158	176	334

Appendix Table 2 continued - HAUL 6.

Length (cm)	Females							Total	Males	Total
	1	2	3	4	5	6	7			
22	1	-	-	-	-	-	-	1	-	1
23	-	-	-	-	-	-	-	0	-	0
24	-	-	-	-	-	-	-	0	-	0
25	-	-	-	-	-	-	-	0	-	0
26	-	-	-	-	-	-	-	0	-	0
27	-	-	-	-	-	-	-	0	-	0
28	-	-	-	-	-	-	-	0	-	0
29	-	-	-	-	-	-	-	0	-	0
30	-	-	-	-	-	-	-	0	-	0
31	-	-	-	-	-	-	-	0	-	0
32	-	-	-	-	-	-	-	0	-	0
33	-	-	-	-	-	-	-	0	-	0
34	-	-	-	-	-	-	-	0	-	0
35	-	-	-	-	-	-	-	0	-	0
36	-	-	-	-	-	-	-	0	-	0
37	-	-	-	-	-	-	-	0	-	0
38	-	-	-	-	-	-	-	0	-	0
39	-	-	-	-	-	-	-	0	-	0
40	-	-	-	-	-	-	-	0	-	0
41	-	-	-	-	-	-	-	0	-	0
42	-	-	-	-	-	-	-	0	-	0
43	-	1	-	-	-	-	-	1	-	1
44	-	-	-	-	-	-	-	0	-	0
45	-	-	-	-	-	-	-	0	-	0
46	-	-	-	-	-	-	-	0	-	0
47	-	-	-	-	-	-	-	0	-	0
48	-	-	-	-	-	-	-	0	1	1
49	-	-	-	-	-	-	-	0	1	1
50	-	-	-	-	-	-	-	0	0	0
51	-	-	-	-	-	-	-	0	0	0
52	-	-	-	-	-	-	-	0	0	0
53	-	-	-	-	-	1	-	1	1	2
54	-	-	-	1	-	0	-	1	2	3
55	-	-	1	1	-	0	-	2	1	3
56	-	-	0	2	-	0	-	2	2	4
57	-	-	0	2	-	2	-	4	0	4
58	-	-	0	2	-	0	-	2	1	3
59	-	-	0	1	-	1	-	2	1	3
60	-	-	1	5	-	1	-	7	4	11
61	-	-	-	1	-	5	-	6	3	9
62	-	-	-	3	-	1	-	4	2	6
63	-	-	-	2	2	2	-	6	2	8
64	-	-	-	1	-	3	-	4	1	5
65	-	-	-	1	-	0	-	1	0	1
66	-	-	-	3	-	1	-	4	1	5
67	-	-	-	0	-	1	-	1	0	1
68	-	-	-	1	-	0	-	1	1	2
69	-	-	-	4	-	0	-	4	-	4
70	-	-	-	2	-	0	-	2	-	2
71	-	-	-	0	-	0	-	0	-	0
72	-	-	-	0	-	1	-	1	-	1
73	-	-	-	1	-	-	-	1	-	1
Total	1	1	2	33	2	20	0	59	28	87

Appendix Table 2 continued - HAUL 7.

Length (cm)	Females							Total	Males	Total
	1	2	3	4	5	6	7			
37	-	-	-	-	-	-	-	-	1	1
38	-	-	-	-	-	-	-	-	0	0
39	-	-	-	-	-	-	-	-	1	1
40	-	-	-	-	-	-	-	-	0	0
41	-	-	-	-	-	-	-	-	0	0
42	-	-	-	-	-	-	-	-	1	1
43	-	-	-	-	-	-	-	-	0	0
44	-	-	-	-	-	-	-	-	1	1
45	-	1	1	3	-	-	-	5	1	6
46	-	0	-	0	-	-	-	0	1	1
47	-	0	-	1	-	-	-	1	0	1
48	-	0	-	0	-	-	-	0	0	0
49	-	0	-	1	-	-	-	1	0	1
50	-	0	-	1	-	-	-	1	4	5
51	-	0	-	3	-	-	-	3	1	4
52	-	0	-	1	-	1	-	2	2	4
53	-	1	-	3	-	0	-	4	2	6
54	-	0	-	5	-	0	-	5	2	7
55	-	0	-	3	-	2	-	5	3	8
56	-	0	-	5	-	0	-	5	7	12
57	-	0	-	7	-	2	-	9	5	14
58	-	0	-	2	1	0	-	3	4	7
59	-	0	-	3	0	0	-	3	2	5
60	-	2	-	10	0	1	-	13	5	18
61	-	-	-	5	0	0	-	5	9	14
62	-	-	-	6	1	2	-	9	4	13
63	-	-	-	1	0	0	-	1	7	8
64	-	-	-	11	1	3	-	15	5	20
65	-	-	-	9	0	3	-	12	3	15
66	-	-	-	5	1	3	-	9	4	13
67	-	-	-	4	-	1	-	5	0	5
68	-	-	-	5	-	1	-	6	2	8
69	-	-	-	3	-	1	-	4	0	4
70	-	-	-	2	-	0	-	2	0	2
71	-	-	-	2	-	0	-	2	1	3
72	-	-	-	4	-	1	-	5	1	6
73	-	-	-	2	-	-	-	2	0	2
74	-	-	-	0	-	-	-	0	0	0
75	-	-	-	1	-	-	-	1	1	2
76	-	-	-	0	-	-	-	0	-	0
77	-	-	-	1	-	-	-	1	-	1
78	-	-	-	0	-	-	-	0	-	0
79	-	-	-	0	-	-	-	0	-	0
80	-	-	-	1	-	-	-	1	-	1
81	-	-	-	0	-	-	-	0	-	0
82	-	-	-	0	-	-	-	0	-	0
83	-	-	-	0	-	-	-	0	-	0
84	-	-	-	1	-	-	-	1	-	1
Total	0	4	1	11	4	21	0	141	80	221

Appendix Table 2 continued - HAUL 8.

Length (cm)	Females							Total	Males	Total
	1	2	3	4	5	6	7			
29	-	-	-	-	-	-	-	-	2	2
30	-	-	-	-	-	-	-	-	0	0
31	-	-	-	-	-	-	-	-	0	0
32	-	-	-	-	-	-	-	-	0	0
33	-	-	-	-	-	-	-	-	0	0
34	-	-	-	-	-	-	-	-	0	0
35	-	-	-	-	-	-	-	-	0	0
36	-	-	-	-	-	-	-	-	0	0
37	-	-	-	-	-	-	-	-	0	0
38	-	1	-	-	-	-	-	1	0	1
39	-	0	-	-	-	-	-	0	0	0
40	-	1	-	-	-	-	-	1	0	1
41	-	0	-	-	-	-	-	0	0	0
42	-	1	-	-	-	-	-	1	0	1
43	-	0	-	-	-	-	-	0	0	0
44	-	0	-	-	-	-	-	0	0	0
45	-	0	-	-	-	-	-	0	0	0
46	-	0	-	-	-	-	-	0	0	0
47	-	0	-	-	-	-	-	0	2	2
48	-	0	-	-	-	-	-	0	0	0
49	-	0	-	-	-	-	-	0	0	0
50	-	0	-	-	-	-	-	0	1	1
51	-	0	-	1	-	-	-	1	0	1
52	-	1	-	0	-	-	-	1	0	1
53	-	-	-	0	-	-	-	0	0	0
54	-	-	-	0	-	-	-	0	2	2
55	-	-	-	2	-	-	-	2	1	3
56	-	-	-	2	-	-	-	2	1	3
57	-	-	-	2	-	-	-	2	1	3
58	-	-	-	3	-	-	-	3	3	6
59	-	-	-	2	-	-	-	2	4	6
60	-	-	-	7	-	1	-	8	9	17
61	-	-	-	4	-	0	-	4	3	7
62	-	-	-	7	-	1	-	8	6	14
63	-	-	-	4	-	-	-	4	10	14
64	-	-	-	5	-	-	-	5	2	7
65	-	-	-	7	-	-	-	7	6	13
66	-	-	-	9	-	-	-	9	5	14
67	-	-	-	6	-	-	-	6	6	12
68	-	-	-	7	-	-	-	7	2	9
69	-	-	-	2	-	-	-	2	1	3
70	-	-	-	6	-	-	-	6	1	7
71	-	-	-	4	-	-	-	4	0	4
72	-	-	-	2	-	-	-	2	0	2
73	-	-	-	1	-	-	-	1	1	2
74	-	-	-	1	-	-	-	1	-	1
75	-	-	-	2	-	-	-	2	-	2
Total	0	4	0	86	0	2	0	92	69	161

Appendix Table 2 continued - HAUL 9.

Length (cm)	Females							Total	Males	Total
	1	2	3	4	5	6	7			
41	-	1	-	-	-	-	-	1	-	1
42	-	0	-	-	-	-	-	0	1	1
43	-	0	-	-	-	-	-	0	0	0
44	-	0	-	-	-	-	-	0	0	0
45	-	0	-	-	-	-	-	0	1	1
46	-	0	-	-	-	-	-	0	0	0
47	-	0	-	-	-	-	-	0	0	0
48	-	0	-	-	-	-	-	0	1	1
49	-	0	-	-	-	-	-	0	1	1
50	-	0	-	-	-	-	-	0	2	2
51	-	0	-	1	-	-	-	1	3	4
52	-	0	-	1	-	-	-	1	4	5
53	-	0	-	0	-	-	-	0	2	2
54	-	0	-	2	-	-	-	2	8	10
55	-	1	-	6	-	-	-	7	10	17
56	-	-	-	7	-	-	1	8	14	22
57	-	-	-	9	-	-	-	9	16	25
58	-	-	-	10	-	-	-	10	23	33
59	-	-	-	12	-	-	-	12	23	35
60	-	-	-	22	-	2	-	24	27	51
61	-	-	-	17	-	1	-	18	34	52
62	-	-	-	26	2	2	-	30	22	52
63	-	-	-	26	1	0	-	27	29	56
64	-	-	-	27	0	0	-	27	20	47
65	-	-	-	20	0	0	-	20	20	40
66	-	-	-	19	0	0	-	19	23	42
67	-	-	-	27	0	1	-	28	21	49
68	-	-	-	15	0	1	-	16	11	27
69	-	-	-	11	1	-	-	12	10	22
70	-	-	-	14	-	-	-	14	5	19
71	-	-	-	9	-	-	-	9	4	13
72	-	-	-	7	-	-	-	7	0	7
73	-	-	-	7	-	-	-	7	5	12
74	-	-	-	1	-	-	-	1	1	2
75	-	-	-	2	-	-	-	2	-	2
76	-	-	-	0	-	-	-	0	-	0
77	-	-	-	2	-	-	-	2	-	2
78	-	-	-	0	-	-	-	0	-	0
79	-	-	-	1	-	-	-	1	-	1
Total	0	2	0	301	4	7	1	315	341	656

Appendix Table 2 continued - HAUL 12.

Length (cm)	Females							Total	Males	Total
	1	2	3	4	5	6	7			
22	1	-	-	-	-	-	-	1	-	1
23	-	-	-	-	-	-	-	0	-	0
24	-	-	-	-	-	-	-	0	-	0
25	-	-	-	-	-	-	-	0	-	0
26	-	-	-	-	-	-	-	0	-	0
27	-	-	-	-	-	-	-	0	-	0
28	-	-	-	-	-	-	-	0	-	0
29	-	-	-	-	-	-	-	0	-	0
30	-	-	-	-	-	-	-	0	-	0
31	-	-	-	-	-	-	-	0	1	1
32	-	-	-	-	-	-	-	0	0	0
33	-	-	-	-	-	-	-	0	0	0
34	-	-	-	-	-	-	-	0	0	0
35	-	-	-	-	-	-	-	0	0	0
36	-	-	-	-	-	-	-	0	0	0
37	-	-	-	-	-	-	-	0	0	0
38	-	-	-	-	-	-	-	0	2	2
39	-	-	-	-	-	-	-	0	1	1
40	-	-	-	-	-	-	-	0	0	0
41	-	1	-	-	-	-	-	1	0	1
42	-	1	-	-	-	-	-	1	0	1
43	-	0	-	-	-	-	-	0	0	0
44	-	0	-	-	-	-	-	0	0	0
45	-	0	-	-	-	-	-	0	0	0
46	-	0	-	-	-	-	-	0	0	0
47	-	0	-	-	-	-	-	0	0	0
48	-	0	-	-	-	-	-	0	0	0
49	-	0	-	-	-	-	-	0	0	0
50	-	0	-	-	-	-	-	0	0	0
51	-	0	-	-	-	-	-	0	0	0
52	-	1	-	-	-	-	-	1	0	1
53	-	0	-	-	-	-	-	0	0	0
54	-	1	-	1	-	-	-	2	0	2
55	-	1	-	0	-	-	-	1	1	2
56	-	4	-	5	-	-	-	9	3	12
57	-	0	-	4	-	-	-	4	2	6
58	-	3	-	12	-	-	-	15	4	19
59	-	2	-	8	-	-	-	10	9	19
60	-	6	2	14	-	-	-	22	5	27
61	-	2	-	19	-	-	-	21	9	30
62	-	2	-	17	-	1	-	20	8	28
63	-	0	-	17	-	0	-	17	5	22
64	-	2	-	18	-	0	-	20	9	29
65	-	1	-	8	-	0	-	9	12	21
66	-	-	-	8	-	0	-	8	4	12
67	-	-	-	8	-	0	-	8	1	9
68	-	-	-	7	-	0	-	7	2	9
69	-	-	-	2	-	0	-	2	2	4
70	-	-	-	7	-	0	-	7	0	7
71	-	-	-	6	-	1	-	7	0	7
72	-	-	-	2	-	-	-	2	0	2
73	-	-	-	2	-	-	-	2	1	3
74	-	-	-	2	-	-	-	2	0	2
75	-	-	-	0	-	-	-	0	2	2
76	-	-	-	1	-	-	-	1	0	1
77	-	-	-	-	-	-	-	-	1	1
Total	1	27	2	168	0	2	0	200	84	284

Appendix Table 2 continued - HAUL 13.

Length (cm)	Females							Total	Males	Total
	1	2	3	4	5	6	7			
26	-	-	-	-	-	-	-	-	1	1
27	-	-	-	-	-	-	-	-	0	0
28	-	-	-	-	-	-	-	-	0	0
29	-	-	-	-	-	-	-	-	0	0
30	-	-	-	-	-	-	-	-	0	0
31	-	-	-	-	-	-	-	-	0	0
32	-	-	-	-	-	-	-	-	0	0
33	-	-	-	-	-	-	-	-	0	0
34	-	-	-	-	-	-	-	-	0	0
35	-	-	-	-	-	-	-	-	0	0
36	-	-	-	-	-	-	-	-	0	0
37	-	-	-	-	-	-	-	-	0	0
38	-	1	-	-	-	-	-	1	0	1
39	-	1	-	-	-	-	-	1	0	1
40	-	0	-	-	-	-	-	0	0	0
41	-	0	-	-	-	-	-	0	0	0
42	-	1	-	-	-	-	-	1	0	1
43	-	0	-	-	-	-	-	0	0	0
44	-	0	-	-	-	-	-	0	0	0
45	-	0	-	-	-	-	-	0	0	0
46	-	1	-	-	-	-	-	1	0	1
47	-	0	-	-	-	-	-	0	0	0
48	-	0	-	-	-	-	-	0	0	0
49	-	0	-	-	-	-	-	0	0	0
50	-	1	-	-	-	-	-	1	0	1
51	-	0	-	1	-	-	-	1	2	3
52	-	0	-	0	-	-	-	0	0	0
53	-	0	-	1	-	-	-	1	0	1
54	-	0	-	0	-	-	-	0	4	4
55	-	0	-	2	-	-	-	2	2	4
56	-	0	-	2	-	-	-	2	2	4
57	-	2	2	5	-	-	-	9	3	12
58	-	0	-	8	-	-	-	8	6	14
59	-	5	-	8	-	-	-	13	6	19
60	-	1	-	6	-	-	-	7	11	18
61	-	2	-	13	-	-	-	15	15	30
62	-	2	-	12	-	-	-	14	12	26
63	-	2	-	8	-	-	-	10	13	23
64	-	0	-	5	-	-	-	5	8	13
65	-	1	-	12	-	-	-	13	11	24
66	-	0	-	8	-	-	-	8	4	12
67	-	0	-	4	-	-	-	4	6	10
68	-	0	-	4	-	-	-	4	3	7
69	-	0	-	6	-	-	-	6	2	8
70	-	0	-	5	-	-	-	5	4	9
71	-	1	-	4	-	-	-	5	3	8
72	-	-	-	0	-	-	-	0	1	1
73	-	-	-	1	-	-	-	1	1	2
74	-	-	-	1	-	-	-	1	3	4
75	-	-	-	1	-	-	-	1	-	1
Total	0	21	2	117	0	0	0	140	123	263

Appendix Table 2 continued - HAUL 15.

Length (cm)	Females							Total	Males	Total
	1	2	3	4	5	6	7			
21	1	-	-	-	-	-	-	1	-	1
22	0	-	-	-	-	-	-	0	-	0
23	1	-	-	-	-	-	-	1	1	2
24	0	1	-	-	-	-	-	1	0	1
25	1	-	-	-	-	-	-	1	0	1
26	-	0	-	-	-	-	-	0	0	0
27	-	0	-	-	-	-	-	0	0	0
28	-	0	-	-	-	-	-	0	2	2
29	-	0	-	-	-	-	-	0	0	0
30	-	1	-	-	-	-	-	1	1	2
31	-	1	-	-	-	-	-	1	1	2
32	-	0	-	-	-	-	-	0	0	0
33	-	0	-	-	-	-	-	0	0	0
34	-	0	-	-	-	-	-	0	1	1
35	-	0	-	-	-	-	-	0	2	2
36	-	0	-	-	-	-	-	0	0	0
37	-	0	-	-	-	-	-	0	0	0
38	-	1	-	-	-	-	-	1	0	1
39	-	1	-	-	-	-	-	1	1	2
40	-	2	0	-	-	-	-	2	2	4
41	-	0	1	-	-	-	-	1	1	2
42	-	1	0	-	-	-	-	1	0	1
43	-	1	0	-	-	-	-	1	1	2
44	-	0	0	-	-	-	-	0	0	0
45	-	0	0	-	-	-	-	0	0	0
46	-	1	0	-	-	-	-	1	2	3
47	-	1	0	-	-	-	-	1	0	1
48	-	1	0	-	-	-	-	1	0	1
49	-	0	0	-	-	-	-	0	1	1
50	-	0	0	1	-	-	-	1	1	2
51	-	1	0	0	-	-	-	1	2	3
52	-	1	0	1	-	-	-	2	1	3
53	-	0	0	1	-	-	-	1	0	1
54	-	2	0	2	-	-	-	4	4	8
55	-	0	1	7	-	-	-	8	6	14
56	-	0	1	7	-	-	-	8	3	11
57	-	1	0	7	-	-	-	8	1	9
58	-	1	0	1	-	-	-	2	1	3
59	-	1	0	1	-	-	-	2	1	3
60	-	0	0	1	-	-	-	1	1	2
61	-	1	0	2	-	-	-	3	3	6
62	-	1	0	3	-	-	-	4	1	5
63	-	-	0	3	-	-	-	3	3	6
64	-	-	1	1	-	-	-	2	2	4
65	-	-	1	1	-	-	-	2	1	3
66	-	-	1	1	1	-	-	3	5	8
67	-	-	1	1	-	-	-	2	3	5
68	-	-	-	8	-	-	-	8	3	11
69	-	-	-	5	-	1	-	6	3	9
70	-	-	-	14	-	-	-	14	3	17
71	-	-	-	4	-	-	-	4	3	7
72	-	-	-	6	-	-	-	6	3	9
73	-	-	-	3	-	-	-	3	3	6
74	-	-	-	3	-	-	-	3	2	5
75	-	-	-	1	-	-	-	1	1	2
76	-	-	-	3	-	-	-	3	3	6
77	-	-	-	3	-	-	-	3	1	4
78	-	-	-	1	-	-	-	1	1	2
79	-	-	-	1	-	-	-	1	1	2
80	-	-	-	3	-	-	-	3	3	6
81	-	-	-	0	-	-	-	0	0	0
82	-	-	-	0	-	-	-	0	0	0
83	-	-	-	1	-	-	-	1	1	2
84	-	-	-	0	-	-	-	0	0	0
85	-	-	-	0	-	-	-	0	0	0
86	-	-	-	1	-	-	-	1	1	2
87	-	-	-	0	-	-	-	0	0	0
88	-	-	-	0	-	-	-	0	0	0
89	-	-	-	0	-	-	-	0	0	0
90	-	-	-	0	-	-	-	0	0	0
91	-	-	-	1	-	-	-	1	-	1
Total	3	15	5	216	1	1	0	241	139	380

Appendix Table 3. Length frequency of Pacific cod sampled, by haul, by sex, during the FV BLUE WATERS cruise to Hecate Strait, January 30 - February 11, 1989. (Excluding those sampled by maturity stage - see Appendix table 2.)

Length (cm)	Haul 3		Haul 5		Haul 10		Haul 11	
	Mal	Fem	Mal	Fem	Mal	Fem	Mal	Fem
24	-	-	1	-	-	-	-	-
25	-	-	0	-	-	-	-	-
26	-	-	0	-	-	-	-	-
27	-	-	0	-	-	-	-	-
28	-	-	0	-	-	-	-	-
29	-	-	0	-	-	-	-	-
30	-	-	0	-	-	-	-	-
31	-	-	0	-	-	-	-	-
32	-	-	0	-	-	-	-	-
33	-	-	0	-	-	-	-	-
34	-	1	0	-	-	-	-	-
35	-	0	0	-	-	-	-	-
36	-	0	0	-	-	-	-	-
37	-	0	0	-	-	-	-	-
38	-	0	0	-	-	-	-	-
39	1	0	1	-	-	-	-	-
40	0	0	0	-	-	-	-	-
41	0	0	0	-	-	-	-	-
42	0	0	0	1	-	-	1	-
43	0	0	0	0	-	-	0	-
44	0	0	0	0	-	1	0	-
45	0	0	1	0	-	0	0	-
46	0	0	0	0	-	0	0	-
47	0	0	0	0	-	0	0	-
48	0	0	1	0	-	0	0	-
49	0	0	1	0	-	0	0	-
50	0	0	1	0	1	1	0	-
51	0	0	0	0	0	0	0	-
52	0	0	0	1	0	0	0	-
53	0	0	0	2	0	0	0	-
54	0	0	2	0	1	0	0	-
55	1	0	1	1	1	1	0	1
56	-	0	1	1	0	1	1	0
57	-	0	4	1	0	0	1	0
58	-	0	1	1	1	0	0	1
59	-	1	1	2	2	0	0	0
60	-	-	1	3	3	1	0	0
61	-	-	0	2	4	2	0	0
62	-	-	1	6	0	0	1	0
63	-	-	3	1	1	1	-	1
64	-	-	5	3	0	0	-	1
65	-	-	4	7	0	1	-	1
66	-	-	2	7	0	1	-	2
67	-	-	1	5	1	1	-	-
68	-	-	2	5	-	-	-	-
69	-	-	2	3	-	-	-	-
70	-	-	4	3	-	-	-	-
71	-	-	1	1	-	-	-	-
72	-	-	2	3	-	-	-	-
73	-	-	2	0	-	-	-	-
74	-	-	1	1	-	-	-	-
75	-	-	1	2	-	-	-	-
76	-	-	-	4	-	-	-	-
77	-	-	-	0	-	-	-	-
78	-	-	-	2	-	-	-	-
79	-	-	-	1	-	-	-	-
Total	2	2	49	69	15	11	4	7
Total by haul	4		118		26		11	

Appendix Table 4. Length frequency of English sole sampled, by haul, by sex, and by maturity (females only), during the FV BLUE WATERS cruise to Hecate Strait, January 30-February 11, 1989.

Length (cm)	Haul 1			Haul 3		Haul 6			Haul 7		
	Females					Females			Females		
	Males	Females		Males	Fem.	Males	Females		Males	Females	
		Imm.	Mat.				Imm.	Mat.		Imm.	Mat.
17	-	1	-	-	-	1	-	-	1	-	-
18	-	0	-	-	-	2	-	-	1	1	-
19	-	0	-	-	-	2	1	-	5	4	-
20	-	0	-	1	0	2	3	-	1	3	-
21	-	0	-	1	1	2	1	-	16	11	-
22	4	0	-	5	6	3	3	-	4	6	-
23	1	3	-	1	3	4	4	-	6	7	-
24	9	6	-	8	11	7	7	-	16	8	-
25	7	9	-	11	6	5	6	-	15	10	-
26	20	5	-	19	18	8	10	-	10	2	-
27	1	0	-	2	1	5	0	-	1	5	-
28	2	9	-	2	1	4	6	-	1	5	-
29	3	0	-	3	1	5	6	-	8	11	-
30	24	5	-	3	7	5	3	-	6	13	-
31	18	6	-	2	1	1	7	-	1	5	-
32	25	1	-	1	15	1	3	-	1	9	-
33	13	2	-	20	8	2	3	-	1	4	-
34	10	5	-	6	23	-	1	-	0	4	-
35	8	7	-	10	15	-	-	1	1	2	-
36	-	1	-	1	2	-	-	-	-	4	-
37	-	1	-	1	8	-	-	1	-	4	-
38	-	1	-	-	17	-	-	0	-	4	-
39	-	0	-	-	7	-	-	1	-	0	-
40	-	-	-	-	10	-	-	2	-	0	-
41	-	-	-	-	5	-	-	0	-	0	-
42	-	-	-	-	6	-	-	1	-	0	-
43	-	-	-	-	0	-	-	-	-	1	-
44	-	-	-	-	3	-	-	-	-	0	-
45	-	-	-	-	1	-	-	-	-	1	-
Total	205	216	88	242	239	60	61	28	107	103	24

Appendix Table 4 continued.

Length (cm)	Haul 10			Haul 11		Haul 14		
	Females			Males	Fem.	Females		
	Males	Imm.	Mat.			Males	Imm.	Mat
20	-	-	-	-	-	-	1	-
21	-	-	-	-	-	-	0	-
22	-	-	-	-	-	-	0	-
23	-	-	-	-	-	-	0	-
24	-	1	-	-	-	-	0	-
25	-	0	-	-	-	-	0	-
26	-	0	-	-	-	-	0	-
27	-	4	-	-	-	-	9	-
28	-	5	-	-	-	-	8	-
29	-	7	-	-	-	-	7	-
30	-	10	-	-	-	-	16	-
31	-	13	-	-	-	-	15	-
32	-	15	-	-	-	-	18	-
33	1	23	2	6	1	3	17	1
34	0	5	4	7	2	1	3	1
35	0	13	8	2	3	0	9	0
36	0	12	1	3	16	4	3	0
37	0	17	2	5	2	2	7	1
38	0	6	3	3	5	2	4	2
39	0	1	2	1	1	2	0	1
40	1	1	5	-	1	1	1	4
41	1	-	5	-	0	-	1	4
42	1	-	0	-	3	-	1	0
43	-	-	1	-	4	-	-	4
44	-	-	3	-	4	-	-	4
45	-	-	7	-	1	-	-	4
46	-	-	2	-	2	-	-	0
47	-	-	3	-	2	-	-	0
48	-	-	3	-	2	-	-	0
49	-	-	2	-	-	-	-	0
50	-	-	1	-	-	-	-	0
51	-	-	-	-	-	-	-	0
52	-	-	-	-	-	-	-	0
53	-	-	-	-	-	-	-	1
Total	69	149	198	45	262	218	140	102